U.S. Department of Transportation
United States Coast Guard

Commander
Eleventh Coast Guard District

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16478
Ser: oan 386-02
October 8, 2002

Department of Toxic Substances Control
Attn: Mr. Tayseer Mahmoud
5796 Corporate Way
Cypress, CA 90630

Dear Sir:

The Coast Guard believes that no further action is necessary or warranted at our fixed aquatic Aids to Navigation (AtoN) Sites. We request your concurrence. Enclosure (1) contains supporting details.

There are 812 active and discontinued fixed aquatic AtoN sites in California. Of these, 34 sites held 264 batteries. It is unlikely that contaminants have been released from the 148 batteries recovered intact. In addition, 10 AtoN are located where periodic dredging potentially removed contaminants.

Five detailed risk assessments were conducted in representative environments. In all cases, these studies found a minimal risk to human receptors. In most cases, the studies also found that there is only a minimal risk to ecological receptors that can be attributed to batteries. Where there was an increased risk attributable to batteries, it was at levels typically resulting in sub-acute effects to aquatic organisms. The area of affect is limited to 10 meters from abandoned batteries.

Abandoned batteries recovered from California waters likely released few contaminants to the environment. Furthermore, dredging may have removed some contaminants. Remaining contaminants pose minimal risk to human health. Threat to ecological receptors is limited in nature and spatially limited to the immediate area of the AtoN. We believe no further action is either necessary or warranted for fixed aquatic AtoN sites.

LT Matt Braden, (510) 437-2978 is your point of contact concerning our battery survey and recovery program.

Sincerely,

M. L. Van H

M. L. VAN HOUTEN
U. S. Coast Guard
Chief, Aids to Navigation Section
By direction of the District Commander

Enclosure (2 copies)

Copy: Dr. Brian Davis, Department of Toxic Substances Control (w)

CALIFORNIA FIXED AQUATIC AIDS TO NAVIGATION
REQUESR FOR DETERMINATION OF NO FURTHER ACTION
INFORMATION SUMMARY

Prepared by CEU Oakland
September 2002

EXECUTIVE SUMMARY

This information was requested by DTSC in support of a request for a determination of no further action regarding fixed aquatic Aids to Navigation (AtoN). Approximately 264 batteries were discovered at 34 of the 812 active and discontinued AtoN in California. We recovered 148 intact making it unlikely that constituents of concern were released. Of the 34 AtoN, 10 are likely to be periodically dredged.

The United States Coast Guard (USCG) performed a risk assessment program to prioritize battery recovery operations. Most California AtoN were considered to be low risk. Five detailed risk assessments in representative environments were conducted. These studies found minimal risk to human receptors. The studies also found, in most cases, only minimal risk to ecological receptors attributable to batteries. Where risk was attributable to batteries, it was typically at sub-acute effect levels and limited to within 10 m of batteries.

Of the abandoned batteries recovered from California waters, most probably released few constituents of concern to the environment. Dredging is likely to have removed much of the constituents of concern. Remaining constituents of concern pose minimal risk to human health. Any threat to ecological receptors is likely limited in nature and restricted to the immediate area of the AtoN. We believe no further action is either necessary or warranted for fixed aquatic AtoN.

1.0 INTRODUCTION

Among USCG missions is the maintenance of a system of Aids to Navigation (AtoN). These AtoN assist vessels in the safe passage through near shore and in-shore waters of the United States and its territories. AtoN fall into three categories:

- Fixed locations on shore
- Buoys anchored in a general location
- Fixed locations in water.

The last category, known as "fixed aquatic AtoN" is the subject of our request for determination of no further action.

Among fixed aquatic AtoN, some are unlit and some have electrically powered lights. The lighted fixed AtoN are now powered either by commercial electricity or solar electricity using a rechargeable battery. Non-rechargeable batteries powered some AtoN in the past. Before 1973 there was no policy regarding the disposition of depleted batteries. Some batteries were abandoned in ways we now consider inappropriate.

ENCLOSURE(1)

2.0 DISTRIBUTION OF ABANDONED BATTERIES

A total of 812 fixed aquatic AtoN have been installed in California waters. Of these, 385 AtoN are active (i.e. still in use). The remaining 427 are discontinued (i.e. no longer exist).

Both active and discontinued fixed aquatic AtoN were investigated for the presence of abandoned batteries. An effort was made to locate discontinued AtoN using the published latitude and longitude. When they were located and investigated by divers, 34 AtoN had 264 abandoned batteries, between 1 and 61 per AtoN (see Table 1). No batteries were found at the other sites. Site plots for 30 of the 34 sites are included (see Appendix A). Of the sites without plots, one is reported having one battery, the other three sites held two, four, and five batteries.

Table 1
Number Of Batteries Per Site

Number of sites	Number of batteries per site
7	1
6	2
3	3
4	4
1	5
4	6
2	8
1	11
1	14
1	16
1	22
1	23
1	28
1	61

Of the 264 recovered batteries, 148 were intact. An estimated 116 batteries were reported as being ruptured. (Note that the numbers of ruptured batteries is imprecise owing to the difficulty of relating pieces to whole batteries.)

Most of the 240 batteries were found in San Francisco Bay and its adjacent rivers and channels. All of these locations are in marine to fresh water with significant tides and currents. One battery was recovered from the Newport Bay Channel, near Los Angeles. Seventeen batteries were found in Moss Landing, a harbor in Monterey Bay. Six batteries were found in Bodega Bay. These are all in salt water.

Of the 34 AtoN locations with batteries, 24 are located away from navigation channels. Dredging is unlikely to have occurred near these AtoN. The other 10 are located adjacent to channels that are periodically dredged. It is likely that dredging has occurred at these AtoN.

3.0 CONSTITUENTS OF CONCERN

Of the 264 recovered batteries, 259 were the "primary" type. Primary batteries use a zinc-caustic chemistry and may have contained up to 20 grams of mercury when new and fully charged (Morel and Mason, undated and included as Appendix B). The remaining five batteries are the "secondary" type using lead-acid chemistry as found in automobile batteries.

Nine potential constituent metals of concern, found in Table 2, might be found in the two types of batteries. Non-metal constituents of the batteries consist of the plastic or rubber inert case and the liquid components. Because of their aqueous nature, the liquid components are presumed to dissolve and disperse shortly after battery abandonment.

Table 2
Constituent Metals Of Concern

Constituent	Primary battery	Secondary battery
Antimony		
Arsenic		
Cadmium		
Copper	X	X
Lead		X
Mercury	X	
Nickel		
Selenium		
Zinc	X	

Each constituent of concern does not have the same impact in the environment. The main constituent of concern in primary batteries, by weight, is zinc. Up to 20 grams of mercury was added to enhance battery performance. The main constituent of concern in secondary batteries, by weight, is lead. The other constituents of concern were listed on various material safety data sheets or added at the request of the Department of Toxic Substances Control (DTSC). Mercury is considered the most threatening constituent of concern because of the risk it poses to humans who consume contaminated fish, the extremely low levels at which it causes harm, and its bioaccumulative properties.

Morel and Mason (undated) evaluated the fate of mercury in abandoned primary batteries. They concluded that a typical discharged primary battery would have a potential for containing 10 grams of mercury at the time of abandonment. From the analysis of recovered batteries, they determined that intact batteries generally do not release measurable amounts of mercury. Using Morel and Mason's findings, the estimated 116 ruptured batteries are estimated to have released 1.16 kilograms of mercury, or approximately 2.5 pounds into California waters.

4.0 NATIONAL PLAN FOR ATON BATTERY RECOVERY, PRIORITY RANKING PLAN

The USCG established the National Plan for AtoN Recovery and Disposal (National Plan) in 1995 to address abandoned batteries (USCG, 1995). Contained in the National Plan is a Priority Ranking Plan for AtoN Recovery (Ranking Plan). Measures recommended by the Priority Ranking Plan (and since completed) to reduce the problem and prevent additional releases included:

- Convert battery-powered AtoN to solar power
- Implement policies prohibiting the improper disposal of batteries
- Develop a tracking system for every battery in inventory and in use
- Begin a systematic nationwide program to recover abandoned batteries

The Priority Ranking Plan developed the Priority Ranking Model to focus recovery efforts. The criteria of the Model concentrated on potential human health and environmental quality effects. Other factors included impact to public recreation and commercial fisheries. Specific criteria were:

- Projected number of batteries (potential contaminant load)
- Bottom type (battery breakage, fishery potential)
- Sediment type (methylation of mercury)
- Beneficial use of water (drinking water potential)
- Depth and temperature (recreational swimming and diving)

Five priorities were established to focus battery recovery efforts as follows:

- Priority 1: Generally freshwater, very shallow, or terrestrial sites with high projected numbers of batteries in areas with dense human populations. Recreation, diving or drinking water use increased the score. Fined grained sediments that promote methylation also increased scores.

- Priority 2: The same as Priority 1 but for fewer batteries.

- Priority 3: Freshwater sites with low expectation of batteries or in remote locations. In marine environments, sites are considered sensitive such as tidal flats or wetlands.

- Priority 4: Sites usually located in saltwater, where human population and the expected occurrence of batteries is low.

- Priority 5: Locations low in all factors, in saltwater, and more than five miles from residential populations.

Maps in the Ranking Plan show 13 sites in California ranked Priority 3. Sites along the southern coast and San Francisco Bay and tributaries were typically ranked Priority 4. The remaining sites, primarily along the coast, were ranked Priority 5.

5.0 OTHER INVESTIGATIONS

Five prototype investigations were conducted by ETC to assess risks posed by abandoned batteries. The lead author for each was Jamie Maughan, Ph.D.

The prototype investigation locations were selected to be environmentally representative areas (Table 3). The locations were chosen to include included salt- and fresh water, tropical, subtropical, and temperate locations, and both Atlantic and Pacific sites.

Table 3. List of prototype investigations and publication date

Site	Date
Chesapeake Bay	March 1994
Tampa Bay	April 1994
Tennessee River	November 1994
Puget Sound	March 1995
Midway Island	October 1996

In each prototype investigation, sediment samples were collected near AtoN, abandoned batteries, and at background locations. Samples were evaluated for sediment type, grain size and total organic carbon (TOC) in all the studies. Mercury concentrations are reported in all the studies. Zinc and methylmercury concentrations were evaluated in all the studies except Chesapeake Bay. Lead was evaluated in the Chesapeake and Tampa Bay studies. Regional concentrations of the constituents of concern were gleaned from other literature sources. Sediment concentration benchmarks below which organisms would be unlikely to be harmed were developed from the literature. Animals were collected to determine metal concentrations in tissue. Tissue concentration was used to evaluate bioaccumulation and risk to higher trophic levels.

5.1 CHESAPEAKE BAY INVESTIGATION

All the information below is extracted from the report, Chesapeake Bay Aid to Navigation (AtoN) Battery Prototype Investigation (Maughan, 1994a).

5.1.1 Sediment analyses

Fifty sediment samples were collected from five AtoN and analyzed for total mercury and total lead. One sediment sample exceeded generally accepted guidelines published by the National Oceanographic and Atmospheric Administration (NOAA) Effects Range Median (ER-M) values. Only samples of fine particle size exceeded NOAA Effects Range-Low (ER-L) guidelines. Data analyses did not indicate trends related to sample depth, proximity to battery, or proximity to AtoN. Sample stations with the highest sediment concentration also had the highest tissue concentration.

5.1.2 Biota analyses

Sessile epifauna were collected from five AtoN for tissue analysis of total mercury and total lead. The five species that were collected were:

- Wedge clam (*Rangia cuneata*)
- Barnacle (*Balanus eburneus*)
- Blue mussel (*Mytilus edulis*)
- Bent mussel (*Brachidontes exustus*)
- Bent mussel (*Brachidontes recurus*)

5.1.3 Risk Assessment

Mercury and lead concentrations in sandy areas were below both local background levels and regional literature values. In areas where the sediment was silty, metal concentration was found to be higher. However, the distribution of concentrations was independent of distance from the AtoN and battery accumulations.

Metal concentrations in tissue were highest at the AtoN with the largest accumulation of batteries. A conclusion based on this correlation is difficult as this was also the siltiest location. Based on the findings at the site, some risk to ecological receptors exists, including higher trophic levels.

5.2 TAMPA BAY INVESTIGATION

All the information below is extracted from the report, Tampa Bay AtoN Battery Prototype Investigation (Maughan, 1994b). Samples were collected from the upper reaches of the Bay, mid-Bay, and coastal sites. This prototype investigation evaluated terrestrial as well as aquatic sites. As this request for a determination of no further action concerns aquatic sites, the results of terrestrial evaluations are not discussed.

5.2.1 Sediment Analyses

During this prototype investigation, 178 sediments samples were collected. An unlighted AtoN (i.e. batteries were never used there) was selected as a background location. Samples were evaluated for mercury, methylmercury, lead, zinc, grain size, and TOC. Mercury concentrations drop with increasing distance from the AtoN. Concentration also appeared to vary in relation to the number of discarded batteries. No mercury was detected at unlighted AtoN. Sediment grain size and TOC appeared to have a greater impact on mercury concentration than other factors. Lead distribution trends were less clear than those of mercury. Unlighted AtoN showed lower concentrations of lead than lighted AtoN. However, concentrations below the detection limit were distributed throughout the locations rather than focused at the unlighted AtoN. Concentrations of zinc were high at the same AtoN where the mercury concentration was high. Concentrations decreased with distance from both batteries and AtoN. Concentrations of zinc were lowest at unlighted AtoN.

5.2.2 Biota Analyses

Sessile and mobile fauna were collected from 10 AtoN in the study area. Biotic tissue was analyzed for total mercury and total lead. Total mercury concentrations were higher in organisms that were attached to batteries rather than to piles except at one AtoN. These species collected were as follows:

- Tunicate (*Styela plicata*)
- Barnacle (*Balanus eburneus*)
- Oyster (*Crassostrea virginica*)
- Bent mussel (*Brachidontes exustus*)
- Limpid (*Crepidula fornicata*)
- Worm (*Diopatra cuprea*)
- Clam (*Anadara transversa*)
- Snail (*Pisania tincta*)
- Sea pen (*Leptogorgia virgulata*)
- Worm (*Neanthes succinea*)
- Snail (*Busycon contrarium*)
- Crab (7 individuals not identified)

5.2.3 Risk Evaluation

The report recognized that the biological data set was limited in number, derived from many species, and included different sized organisms within a species. Consequently, the conclusions were viewed as preliminary.

Metal concentrations in organisms collected from batteries were generally above background. Organisms collected from piles had tissue concentrations of metals below background concentrations. All levels were below half the concentration considered to pose a public health risk by the U.S. Food and Drug Administration (FDA) from the consumption of seafood. Consequently, there is little risk posed to humans from contamination related to batteries.

Mercury and zinc concentrations in sediments did indicate a potential risk to marine organisms. Metal concentrations immediately adjacent to, and within 10 meters (m) of large concentrations of batteries, always exceeded concentrations considered to be the most protective of benthic animals. Outside 10 m there is very little potential for environmental risk.

5.3 TENNESSEE RIVER INVESTIGATION

All the information below is extracted from the report, Tennessee River AtoN Battery Prototype Investigation (Maughan, 1994c). Samples were collected from two reservoirs on the Tennessee River. One reservoir is used for water storage, hydroelectric, and other purposes. It has long retention times and significant draw-downs. The other location was a run-of-the-river reservoir with relatively short retention times and small draw-downs. In both cases, AtoN were selected outside the influence of dredging.

5.3.1 Sediment Analyses

Sixty-three sediment samples were collected and analyzed for mercury, methylmercury, zinc, grain size, and TOC. Lead was not evaluated in this study. The sample sites were categorized as near field samples (less than 10 m from the AtoN) and far field samples (greater than 10 m).

Mercury concentrations at the lighted AtoN in the upper reservoir were substantially higher than the background location. In the lower reservoir there was no significant difference between AtoN and background concentrations. The data do not show a correlation between mercury concentration and the number of batteries found. Average mercury concentrations generally increased in a gross downstream direction. This appears to be related to sediment grain size rather than battery concentration.

Zinc concentration was fairly uniform at near and far field locations. Concentrations at all the lighted AtoN were significantly lower than the background location. The concentrations in the two lakes were not substantially different. The data do not show a correlation between zinc concentration and the number of batteries found.

The ratio of methylmercury to mercury is low. There does not appear to be a correlation between methylmercury concentration and batteries.

Regression analyses for mercury and zinc versus TOC indicate that this sediment characteristic was not a factor related to metal concentration. There did appear to be a weak inverse relationship between sand content and metal concentration. There was no discernable relationship between sediment or TOC versus tissue concentration. The pattern of methylmercury distribution does appear to be related to clay and TOC content.

5.3.2 Biota Analyses

An effort was made to collect both the same species and similar sized individuals at each location. This was reported as being partially successful. Three types of organisms were collected as follows:

- Clam (*C. fluminea*)
- Midge (*Chironomid sp.*)
- Mayfly larvae (*Hexagenia sp.*)

5.3.3 Risk Assessment

The highest mercury concentration in tissue was measured at approximately one half the FDA advisory limit for mussels. Consequently there is little risk to humans.

Exceedences of the NOAA ER-L benchmarks for mercury in tissue were few and random. Most tissue samples contained mercury concentrations a full order of magnitude less than ER-L. No stations exceeded the ER-M benchmark for mercury. There is no apparent relationship between tissue concentrations and batteries. Concentrations of mercury in sediment are not likely to affect benthos.

Samples exceeded ER-L benchmarks for zinc at all locations except the background station in the upper reservoir. The background station in the lower reservoir exceeded ER-M in 60% of the samples. Therefore, although zinc does pose some risk to benthic infauna at all stations, except the one background station, it is difficult to attribute that risk to contamination from AtoN batteries.

5.4 PUGET SOUND INVESTIGATION

All the information below is extracted from the report, Puget Sound AtoN Battery Prototype Investigation (Maughan, 1995). This investigation evaluated three shallow (10-15 m) fixed AtoN sites and one deep water (20-25 m) buoy site. The area selected for the shallow water study, Budd Inlet, is subject to significant freshwater input during high-runoff storm events. It also receives various pollutants from cultural activities typical of a metropolitan area (Olympia, Washington). The deep water study was planned near Bremerton, also a metropolitan area. No batteries were located near the buoy so neither sediment nor biological samples were collected.

5.4.1 Sediment Analyses

Thirty sediment samples were collected and analyzed for mercury, methylmercury, zinc, grain size, and TOC. Lead was not evaluated in this study. The sample sites were categorized as near field samples (less than 10 m from the AtoN) and far field samples (greater than 10 m).

The difference in mercury concentration is not statistically significant among near field, far field, and background samples. Mercury concentrations in sediment did not exceed state standards. The AtoN average concentrations were above the ER-L but below the ER-M. Observed mercury concentrations were within the range of mercury concentration in sediment found in the literature related to the area. There is no apparent trend when observed mercury concentration is plotted against distance from batteries.

The zinc concentrations in two samples collected near battery accumulations (two or more batteries) were two to three times the concentration of other samples near the same AtoN but away from batteries. However, zinc concentrations in sediment were below the state standards, ER-M, and ER-L.

Methylmercury concentrations were within typical ranges cited in literature sources. Grain size analyses found the average sand content to be 31 percent; silt content 47 percent; and clay content 22 percent. TOC content averaged 3.37 percent.

5.4.2 Biota Analyses

Sessile animals were the preferred targets for mercury and zinc analyses and were collected from each AtoN. Where sufficient numbers were not available, Polycheata worms were collected. These were selected based on the association of their feeding habits and the potential for ingesting metals. The organisms collected for tissue metal analyses were:

- Common Pacific littleneck clam (*Protothaca staminae*)
- Nutall's cockle (*Clinocardium nutttallii*)
- Lean Barke-whelt (*Nassarius mendicus*)
- Bent nosed macoma (*Macoma nasuta*)
- Name not legible (*Malcobdella sp.*)
- Frilled anemone (*Meridium senile*)
- Siparid (*Prionospio cirrifera*)

- Brittle star (*Ophiura sp.*)
- Nut shell (*Nuculana cellulitia*)
- None cited (*Cryptomya californica*)
- None cited (*Macoma inquinata*)
- Clamworm (*Nereis brandti*)
- Not legible (*Not legible teserculata*)
- Northern (not legible) anemone (*Tealia crassicornis*)
- None cited (*Hemipodus sp.*)
- Mud worm (*Lumbrineris inflata*)
- Milky venus clam (*Campsomycox subdiaphono*)
- Scale worm (*Polynoidea sp.*)
- Pea crab (*Seleroplax granulata*)
- Ghost shrimp (*Neotrypaea californiensis*)

5.4.3 Risk Assessment

Mercury concentrations in sediment did not exceed state standards. Observed mercury concentrations were within the range of mercury concentrations cited in literature related to the area. Observed zinc concentrations in sediment were below the state standards, ER-M, and ER-L. Methylmercury concentrations were within ranges cited in literature sources. There is no apparent relationship between any metal concentrations and grain size values. Additionally, there is no statistical relationship with TOC content.

The data suggest that batteries may have some impact on zinc but not mercury concentration in the immediate area of batteries. The presence of these metals is not expected to have an adverse affect to humans or biological resources attributable to batteries.

5.5 MIDWAY ISLAND INVESTIGATION

All the information below is extracted from the report, Midway Island AtoN Battery Prototype Investigation (Maughan, 1996). The investigation was performed near Sand Island. One AtoN and one background location were sampled. The AtoN was divided into three plots around three deposits of batteries. Three samples were collected from each plot.

5.5.1 Sediment Analyses

Forty-two sediment samples were collected and analyzed for mercury, zinc, methylmercury, grain size, and TOC. Lead was not evaluated in this study. The average mercury concentration from beneath battery accumulations was very similar to the concentration between battery accumulations. None of the background samples had detectable mercury. Because only three samples (7 percent) had any detectable mercury, it cannot be concluded that the mercury in sediment is due to the presence of batteries. The average sediment concentrations were well below the reference benchmark values of ER-M and ER-L.

The data indicate a direct relationship between distance from batteries and the concentration of zinc in sediments. There is also a relationship between the concentration of zinc in sediments and the number of batteries. It is likely that batteries, at least in piles, are a source of zinc in sediment.

The average concentration of methylmercury was higher in sediment within areas of battery accumulation than areas outside battery accumulations. Statistical analyses of the data indicate that batteries may be affecting methylmercury concentrations in sediment.

5.5.2 Biota Analyses

Marine organisms were collected for analysis. Sampling was similar to previous studies except that a spear gun was used. Two species were selected as the primary targets for biota analyses: *Holothuria atra*, a detrivore sea cucumber, and *Stegastes fasciolatus*, a territorial, algae grazing damsel fish. Although carnivorous, three *Chaetodon ferembolii* were collected, because they were observed feeding on polyps attached to batteries.

Total mercury in *H. atra* was below tissue concentrations from nearby areas as cited in literature sources. The average concentration of mercury in specimens from the background location was higher than the average concentration in specimens from the AtoN plots. It can be concluded that the tissue concentrations of mercury was not due to the presence of batteries.

The *S. fasciolatus* collected from among batteries had a slightly higher concentration than those from other habitats. The difference between tissue concentrations at the AtoN and the background location is statistically significant. However, the relationship found in *C. ferembolii* is just the reverse. Owing to the small number of samples and the dissimilar data, it is not possible to reach any conclusions regarding batteries and tissue mercury concentrations in fish.

5.5.3 Risk Assessment

Zinc and methylmercury concentrations in sediment did appear to be related to accumulations of batteries. Mercury was nearly undetectable in sediment independent of the presence of batteries. The concentration of metals in the bottom feeders was lower in the AtoN area than the background area. Fish collected at the largest accumulation of batteries had a higher mercury concentration in their tissue. However, both had lower concentrations than were reported from other studies in the area.

The report concluded that the sediment concentrations were below levels likely to cause adverse ecological impacts to aquatic animals. Nowhere did the concentrations exceed levels reported in the literature that would be likely to cause adverse effects. There is no demonstrated risk to aquatic animals from the AtoN batteries. Tissue concentrations of mercury related to the AtoN were two orders of magnitude less than FDA advisories. Consequently, there is little risk to humans from fish consumption.

6.0 SUMMARY AND CONCLUSION

Of the approximately 812 active and discontinued fixed aquatic AtoN in California, 264 batteries were discovered at 34 AtoN sites. Of these batteries, 148 were recovered intact. It is unlikely that constituents of concern have been released from the recovered batteries.

Of the 34 AtoN locations that were associated with batteries, 10 are located in areas that are periodically dredged. It is possible that potential contaminants and batteries have been removed by dredging.

The USCG performed a risk assessment program to battery recovery operations. Many of the AtoN sites in California were considered low risk based on the prioritization criteria.

The USCG followed the initial risk evaluation by five detailed risk assessments in representative environments. These studies found in all cases only a minimal risk to human receptors. The studies also found in most cases only a minimal risk to ecological receptors could be attributed to batteries. In those cases where an increased risk was attributable to batteries, it was at a level typically resulting in sub-acute effects. The increased risk is limited to an area within 10 m of abandoned batteries.

Of the abandoned batteries recovered from California waters, most probably released few constituents of concern to the environment. Dredging is likely to have removed much of the constituents of concern. Any remaining constituents of concern pose minimal risk to human health. Any threat to ecological receptors is likely limited in nature and restricted to the immediate area of the AtoN. We believe no further action is either necessary or warranted for fixed aquatic AtoN.

7.0 BIBLIOGRAPHY

Maughan, James T. (1994a). Chesapeake Bay AtoN Battery Prototype Investigation. Prepared by Environmental Transportation Consultants for Volpe National Transportation Center.

Maughan, James T. (1994b). Tampa Bay AtoN Battery Prototype Investigation. Prepared by Environmental Transportation Consultants for Volpe National Transportation Center.

Maughan, James T. (1994c). Tennessee River AtoN Battery Prototype Investigation. Prepared by Environmental Transportation Consultants for Volpe National Transportation Center.

Maughan, James T. (1995). Puget Sound AtoN Battery Prototype Investigation. Prepared by Environmental Transportation Consultants for Volpe National Transportation Center.

Maughan, James T. (1996). Midway Island AtoN Battery Prototype Investigation. Prepared by Environmental Transportation Consultants for Volpe National Transportation Center.

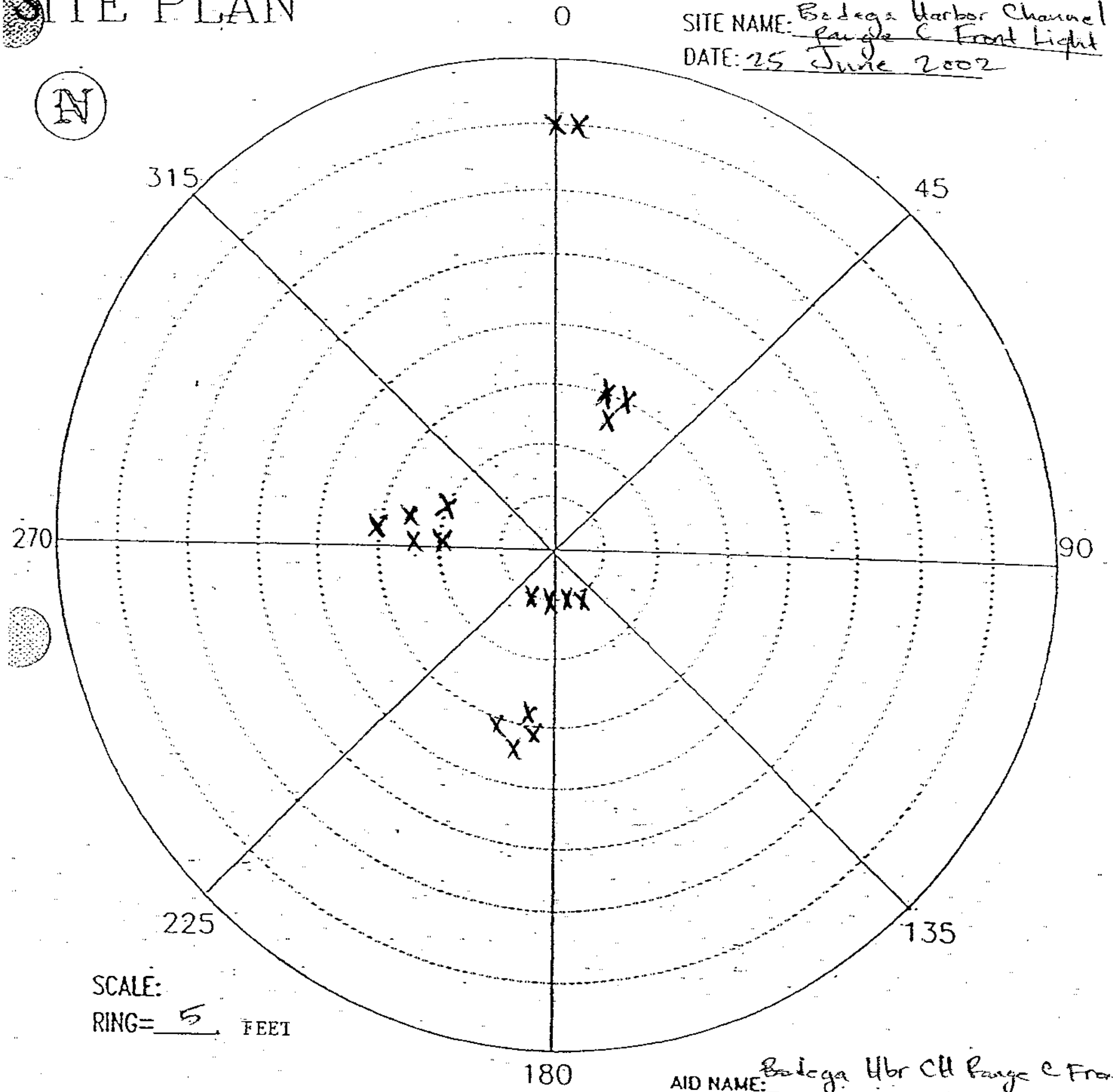
Morel, Francois, & Rob Mason. (undated). The Fate of Mercury from AtoN Batteries, A Report to the Volpe Center. R.M. Parsons Laboratory, MIT

USCG 1995, National Plan for AtoN Battery Recovery and Disposal COMDTINST 16478.12.

APPENDIX A

SITE PLAN

LLNR 7845
SITE NAME: Bodega Harbor Channel Range C Front Light 14
DATE: 25 June 2002



SCALE:
RING= 5 FEET

AID NAME: Bodega Hbr Chl Range C Front Lt 14
LLNR: 7845
POSITION: LAT.
LON

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

SIGNATURE:

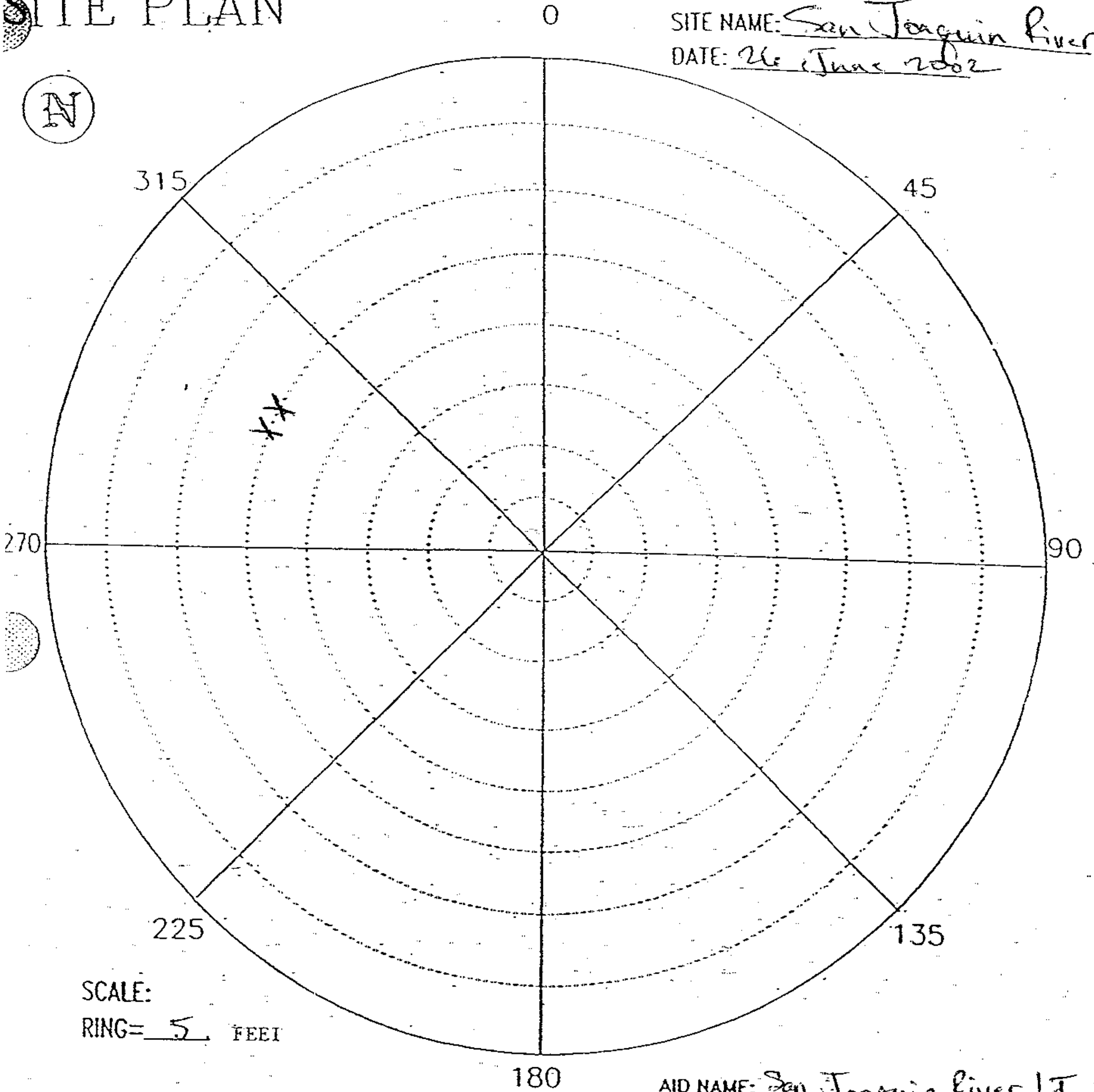
BATTERY TYPE	QTY	CONDITION #INTACT	#RUPTURED
ZINC(MERCURY)			
LEAD ACID	18	18	0
TOTAL L & Z	18	18	0

LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1
A=ATON STRUCTURE

Field Notes 4 of 6

SITE PLAN

SITE NAME: San Joaquin River LT 57
DATE: 26 June 2002



SCALE:
RING= 5 FEET

AID NAME: San Joaquin River LT 57
LLNR: 6895
POSITION: LAT 38° 03' 36" N
LON 121° 33' 18" W

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

SIGNATURE: [signature]

BATTERY TYPE	QTY	CONDITION	
		#INTACT	#RUPTURED
ZINC(MERCURY)			
LEAD ACID	2	2	0
TOTAL L & Z	2	2	0

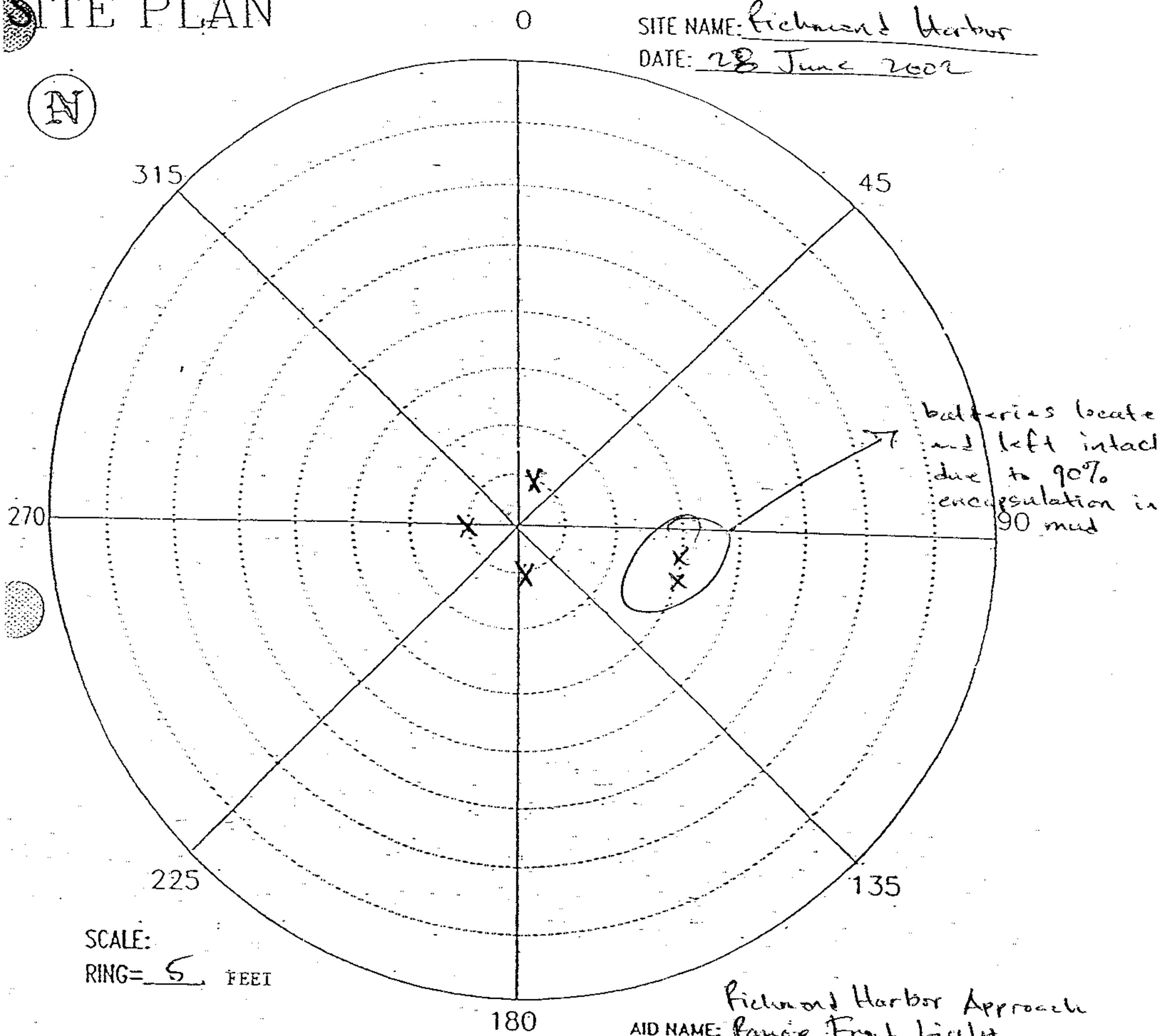
LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1
A=ATON STRUCTURE

Field Notes 8 of

SITE PLAN

SITE NAME: Richmond Harbor

DATE: 28 June 2002



SCALE:

RING= 5 FEET

AID NAME: Richmond Harbor Approach Range Front Light

LLNR: 8670

POSITION: LAT. 37° 54' 00 N

LON 122° 23' 30" W

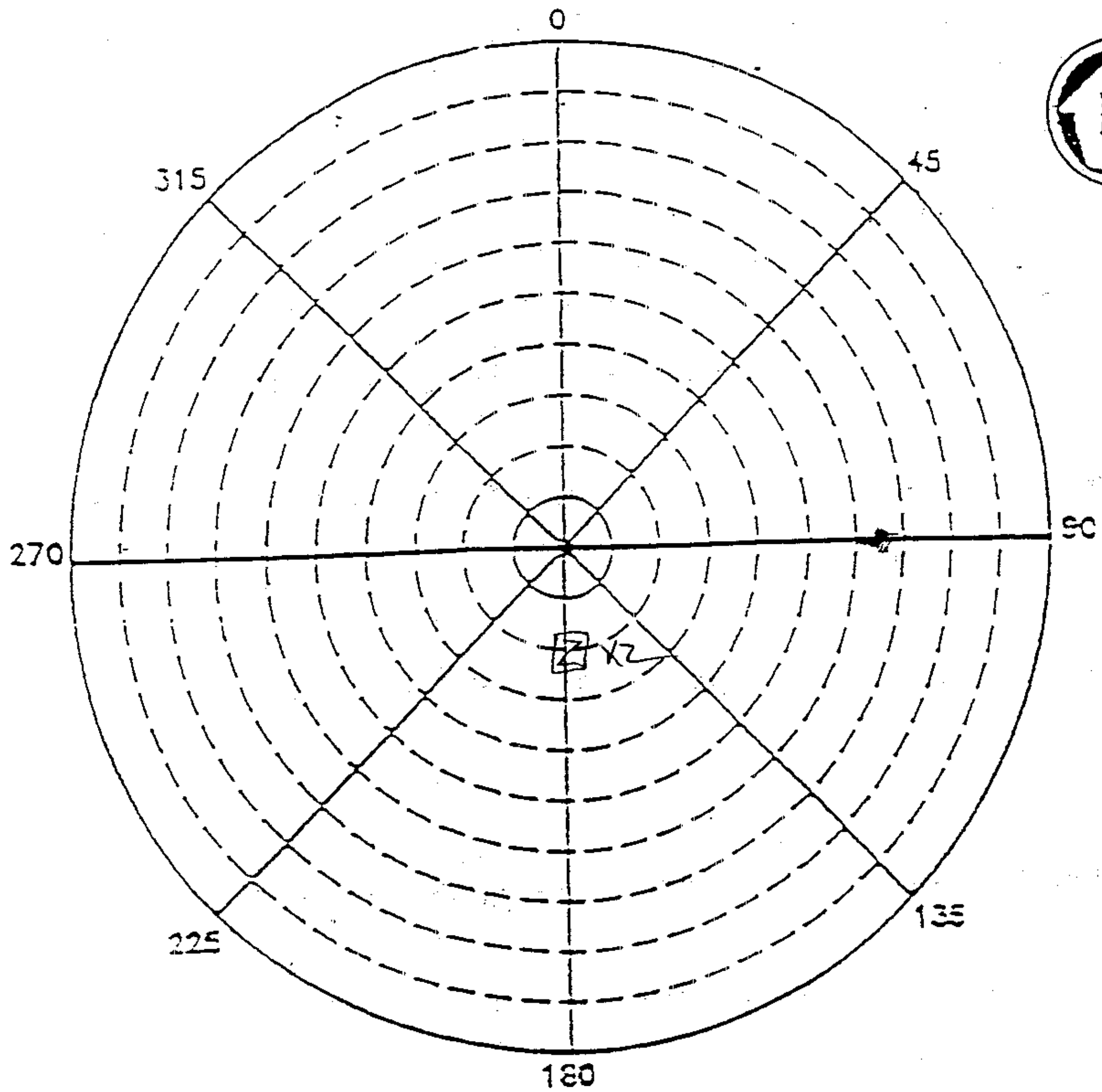
SIGNATURE: [signature]

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

BATTERY TYPE	QTY	CONDITION	
		#INTACT	#RUPTURED
ZINC(MERCURY)			
LEAD ACID	3	3	0
TOTAL L & Z	3	3	0

LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1
A=ATON STRUCTURE

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

Aid Name: Stockton Ch Range D Front Lt.
Aid # (LLNR): 6995.
Position: LAT 38°01 33.291 (N)
LON 121°28 05.072 W
Date: 1-21-97

TABLE

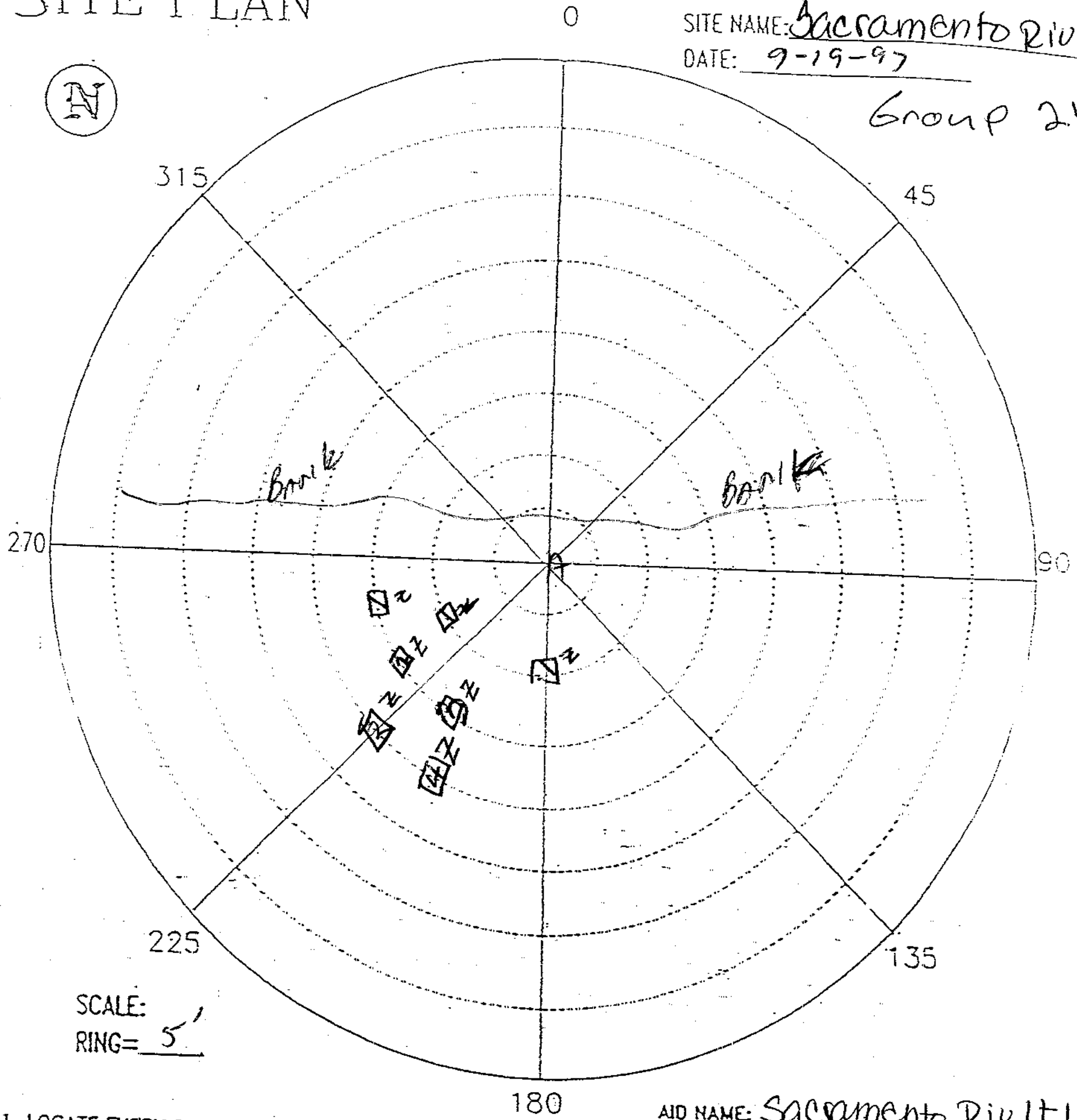
Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid	—	—	—
Zinc (Mercury)	2	—	2
Total L & Z	2	—	2

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

SITE PLAN

SITE NAME: Sacramento Riv Lt 1
DATE: 9-19-97

Group 24



SCALE:
RING= 5'

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

AID NAME: Sacramento Riv Lt 1
LLNR: 7025.00
POSITION: LAT. 38° 16' 40.733N
LON 121° 39' 49.070W

SIGNATURE: V. Watts

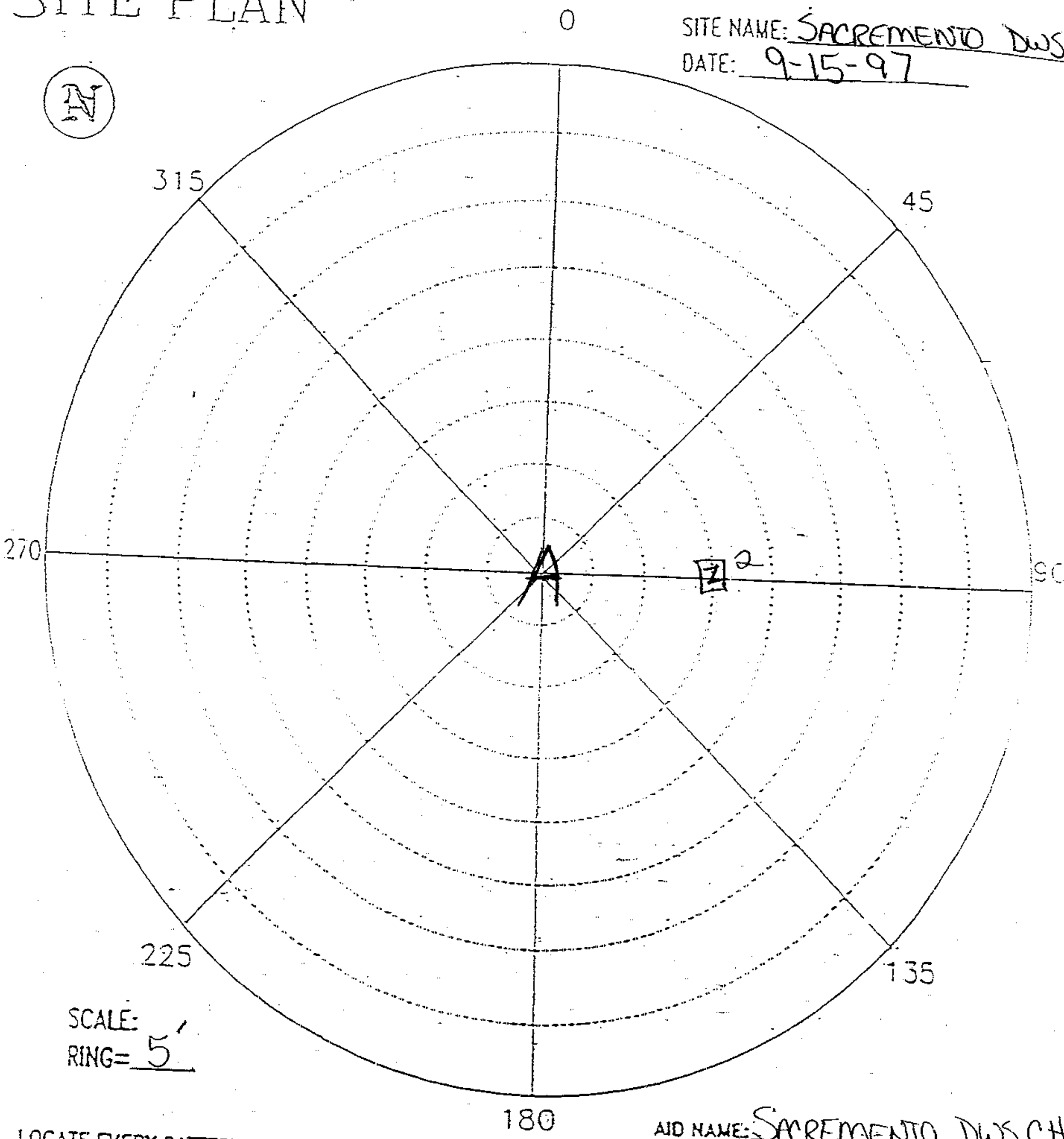
TABLE

BATTERY TYPE	QTY	CONDITION	
		#INTACT	#RUPTURED
ZINC(MERCURY)	14	14	
LEAD ACID			
TOTAL L & Z	14	14	

LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1
A=ATON STRUCTURE

SITE PLAN

SITE NAME: SACREMENTO DWS CH #3
DATE: 9-15-97



SCALE:
RING= 5'

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

AID NAME: SACREMENTO DWS CH #3
LLNR: 7180.00
POSITION: LAT 38° 03' 57.959 N
LON 121° 50' 34.667 W

SIGNATURE: Greg Bosky

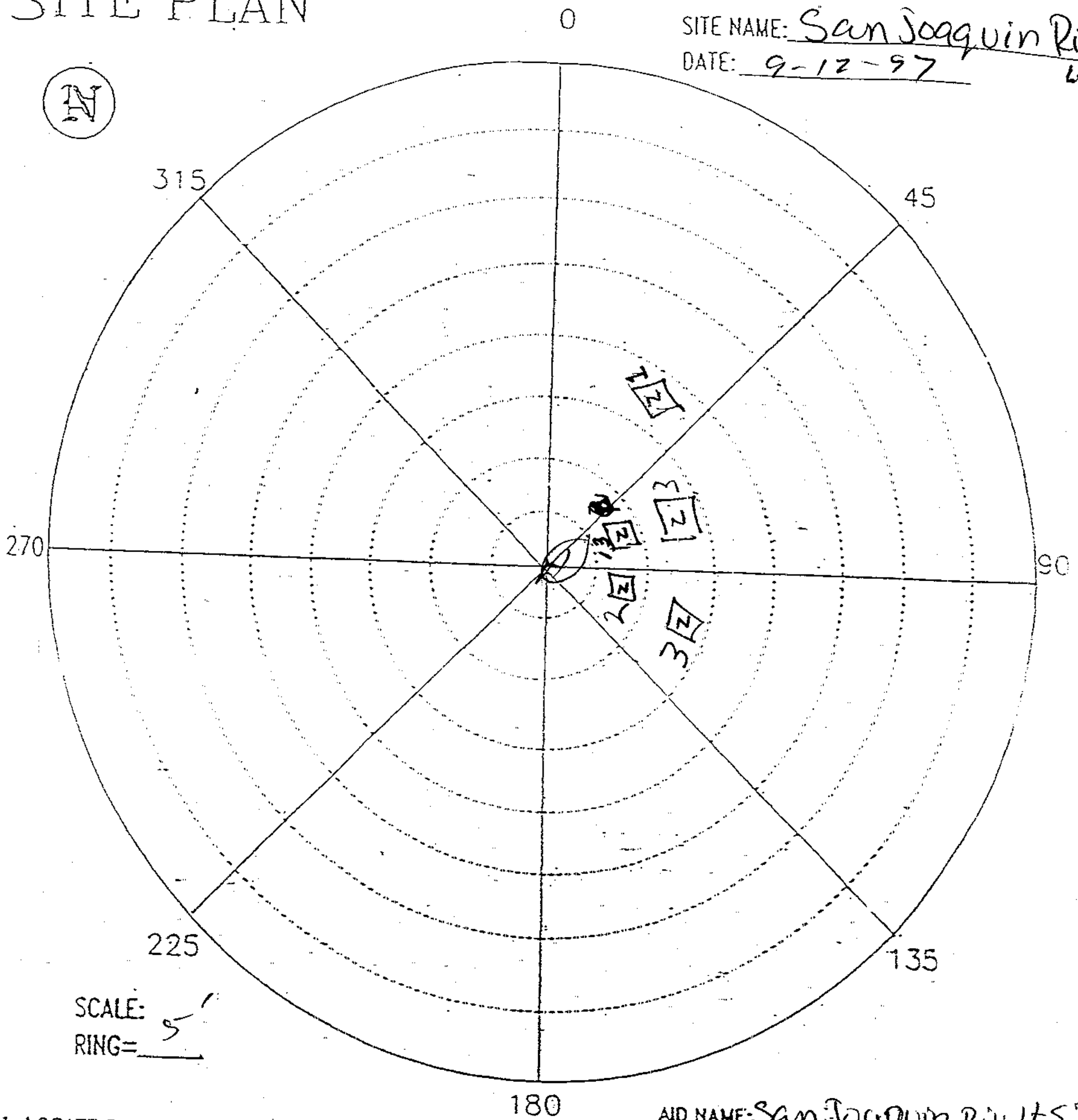
TABLE

BATTERY TYPE	QTY	CONDITION #INTACT	#RUPTURED
ZINC(MERCURY)	2	2	Ø
LEAD ACID			
TOTAL L & Z	2	2	Ø

LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1

SITE PLAN

SITE NAME: San Joaquin Riv Lt S 457
DATE: 9-12-97



SCALE:
RING= 5'

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

AID NAME: San Joaquin Riv Lt 57
LLNR: 6895.00
POSITION: LAT 38 03 38.726 N
LON 121 33 19.852 W

SIGNATURE: V. Watts

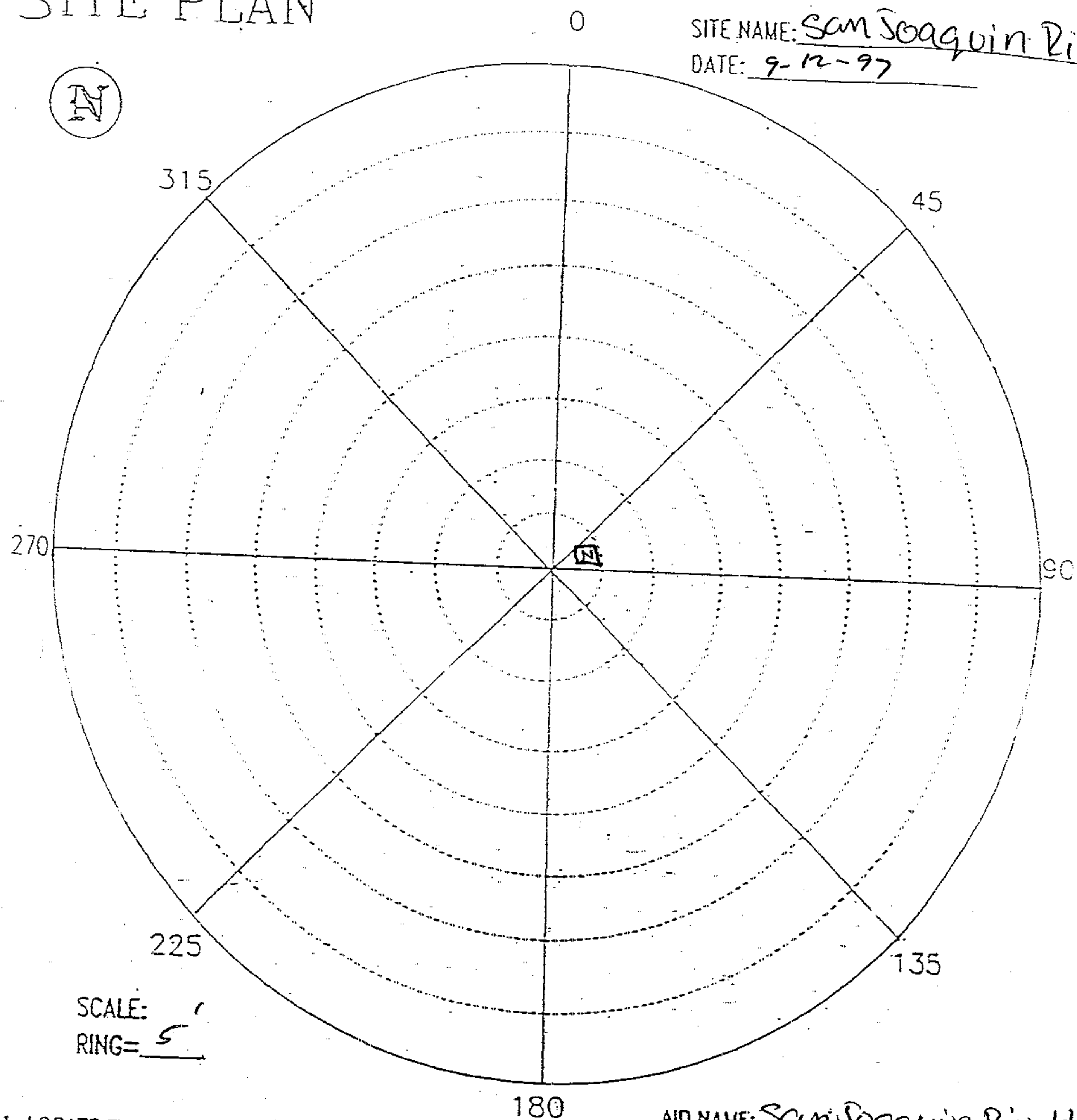
TABLE

BATTERY TYPE	QTY	CONDITION #INTACT	#RUPTURED
ZINC(MERCURY)	22	22	
LEAD ACID			
TOTAL L & Z	22	22	

LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1
A=ATON STRUCTURE

SITE PLAN

SITE NAME: San Joaquin Riv 1758
DATE: 9-12-97



SCALE: 1
RING= 5

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

AID NAME: San Joaquin Riv 1758
LLNR: 6900.00
POSITION: LAT 38°03' 30.702 N
LON 121°33' 24.865 W

SIGNATURE: V. Watts

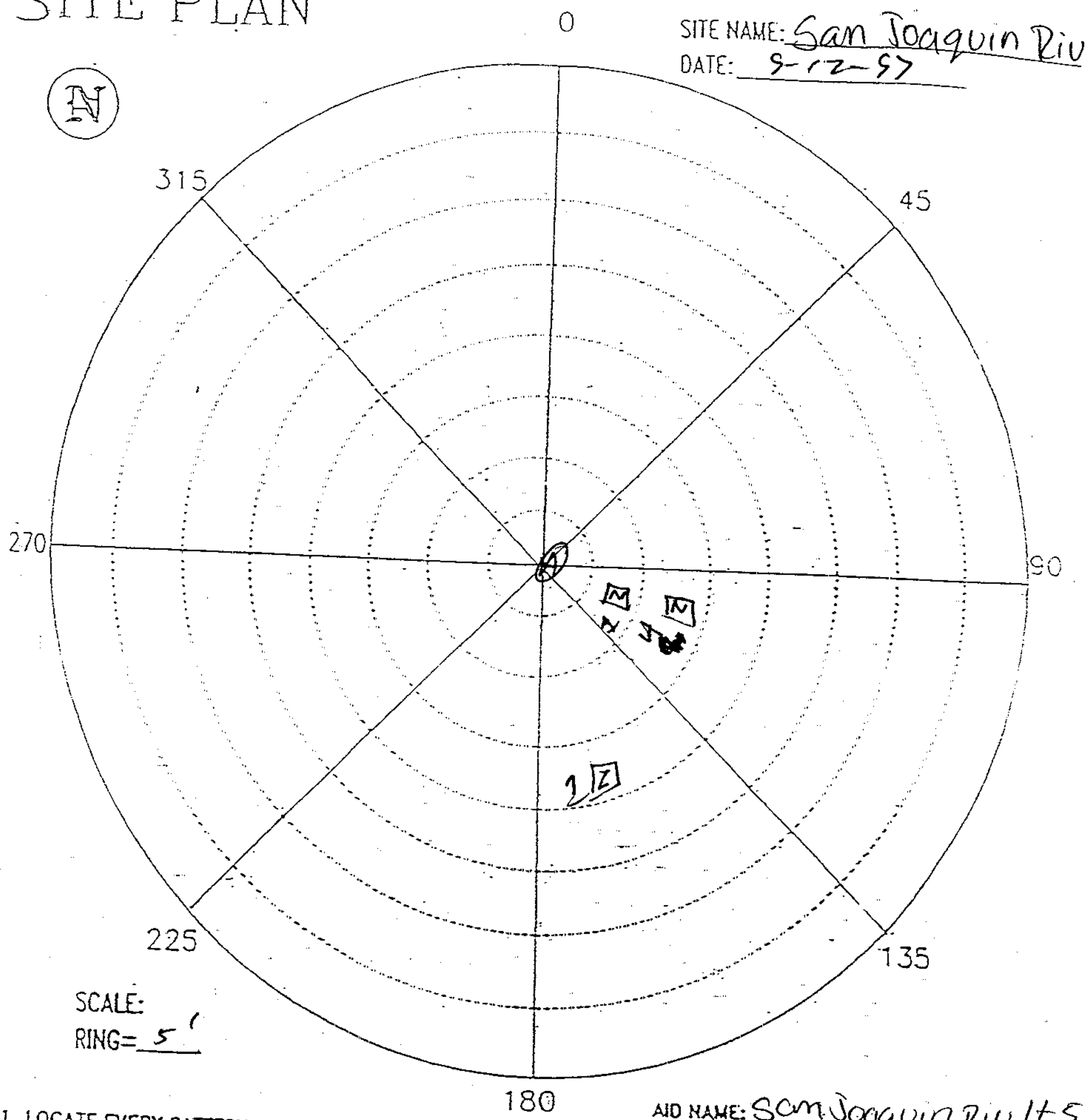
TABLE

BATTERY TYPE	QTY	CONDITION #INTACT	#RUPTURED
ZINC(MERCURY)	1	1	
LEAD ACID		-	
TOTAL L & Z	1	1	

LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1
A=ATON STRUCTURE

SITE PLAN

SITE NAME: San Joaquin Riv Lt 53
DATE: 9-12-97



SCALE:
RING= 5'

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

AID NAME: San Joaquin Riv Lt 53
LLNR: 6875.00
POSITION: LAT 38°04 48.381N
LON 121°34 09.767w

SIGNATURE: [signature]

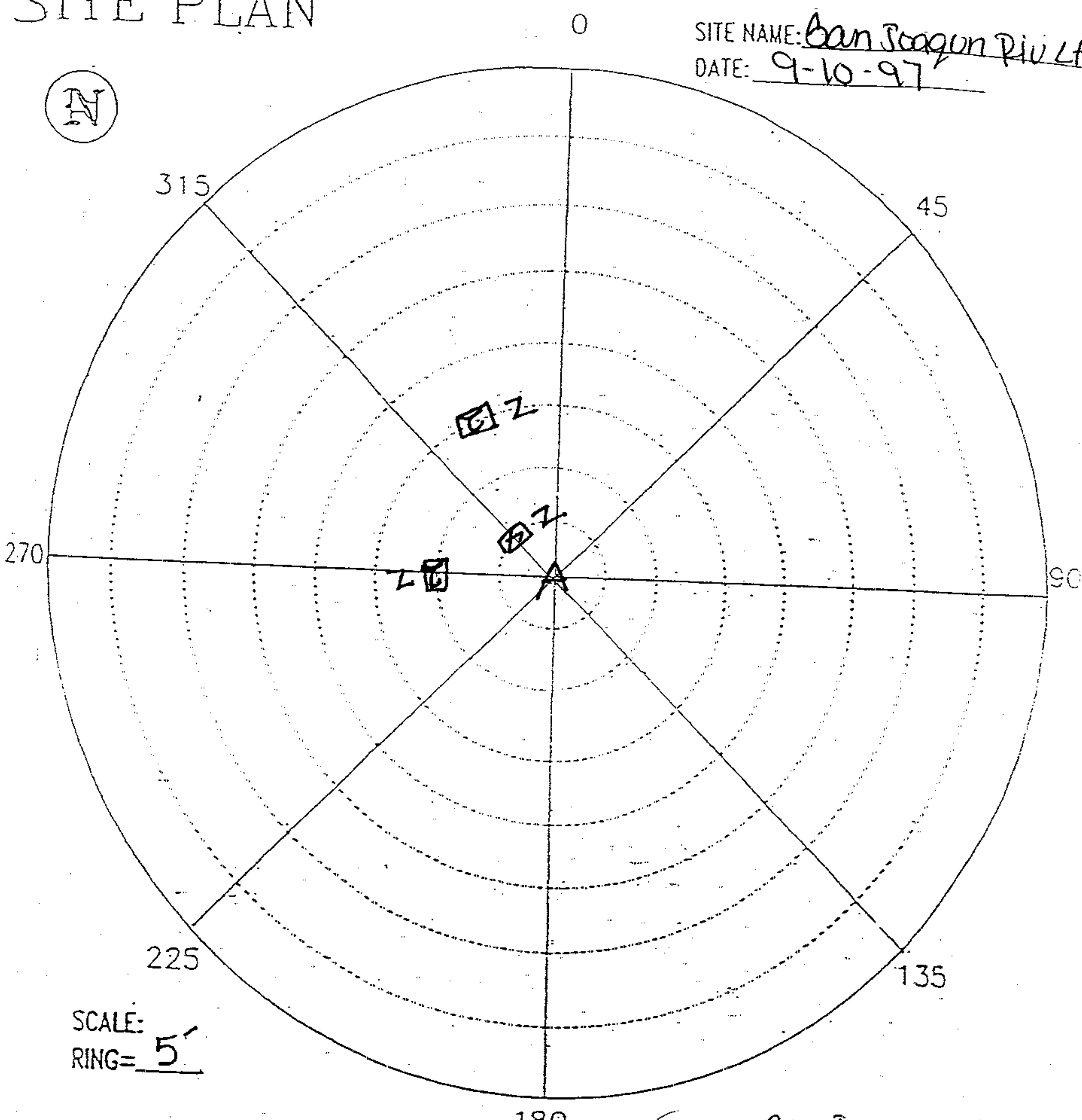
TABLE

BATTERY TYPE	QTY	CONDITION	
		#INTACT	#RUPTURED
ZINC(MERCURY)	6	6	
LEAD ACID			
TOTAL L & Z	6	6	

LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1
A=ATON STRUCTURE

SITE PLAN

SITE NAME: San Joaquin Riv Lt 36
DATE: 9-10-97



SCALE:
RING= 5'

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

AID NAME: San Joaquin Riv Lt 36
LLNR: 6815.00
POSITION: LAT 38°05'07.949N
LON 121°38'28.540W

SIGNATURE: Greg Bosley

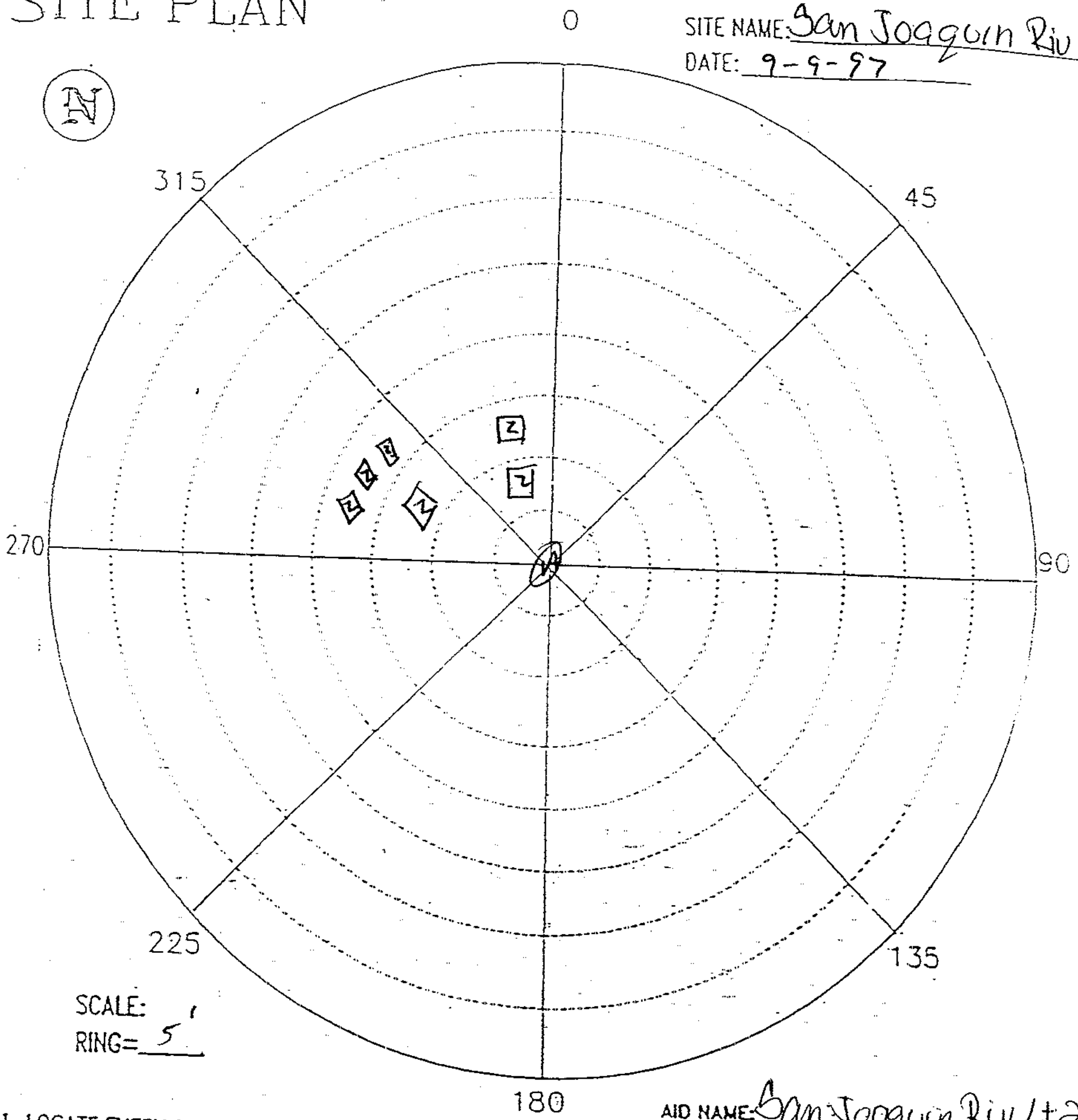
TABLE

TTERY TYPE	QTY	CONDITION	
		#INTACT	#RUPTURED
ZINC(MERCURY)	8	8	
LEAD ACID			
TOTAL L & Z	8	8	

LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1
A=ATON STRUCTURE

SITE PLAN

SITE NAME: San Joaquin Riv Lt 26
DATE: 9-9-97



SCALE:
RING= 5'

AID NAME: San Joaquin Riv Lt 26
LLNR: 0768.00
POSITION: LAT 38°03' 57.686 N
LON 121° 40' 31.430 W

SIGNATURE: V. Watts

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

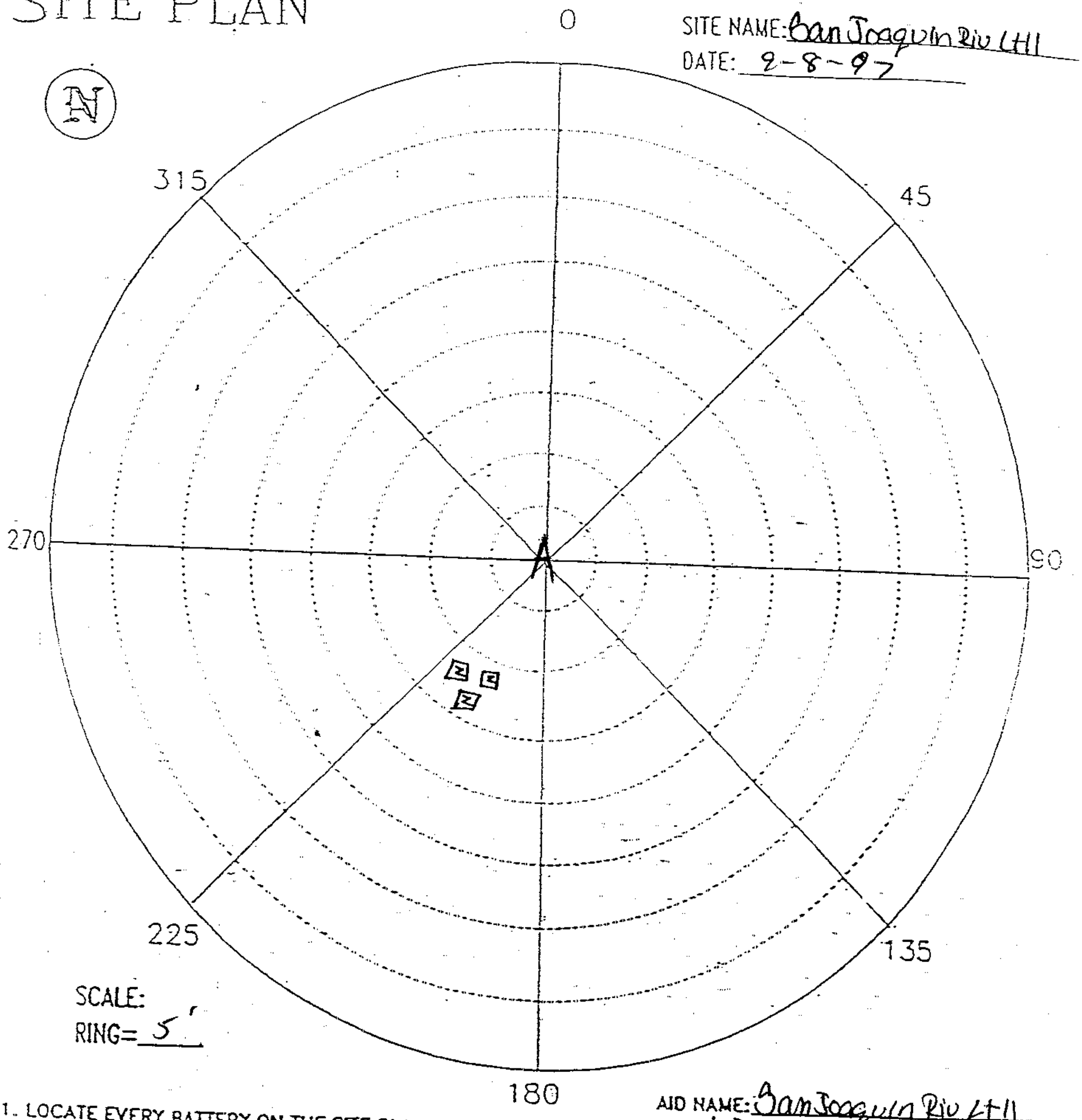
TABLE

BATTERY TYPE	QTY	CONDITION	
		#INTACT	#RUPTURED
ZINC(MERCURY)	6	6	
LEAD ACID			
TOTAL L & Z	6	6	

LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1
A=ATON STRUCTURE

SITE PLAN

SITE NAME: San Joaquin Riv LT11
DATE: 9-8-97



SCALE:
RING= 5'

1. LOCATE EVERY BATTERY ON THE SITE PLAN.
2. THE DATUM IS THE HIGHEST CONCENTRATION OF BATTERIES
3. DENOTE A FIXED REFERENCE OBJECT ON THE SITE PLAN.
4. USE SYMBOLS LISTED ON THE LEGEND.
5. CIRCLE RUPTURED BATTERIES.
6. DRAW A SQUARE AROUND BATTERIES THAT WERE REMOVED.

AID NAME: San Joaquin Riv LT11
LLNR: 6700.00
POSITION: LAT 38°01'46.983N
LON 121°45'59.690W

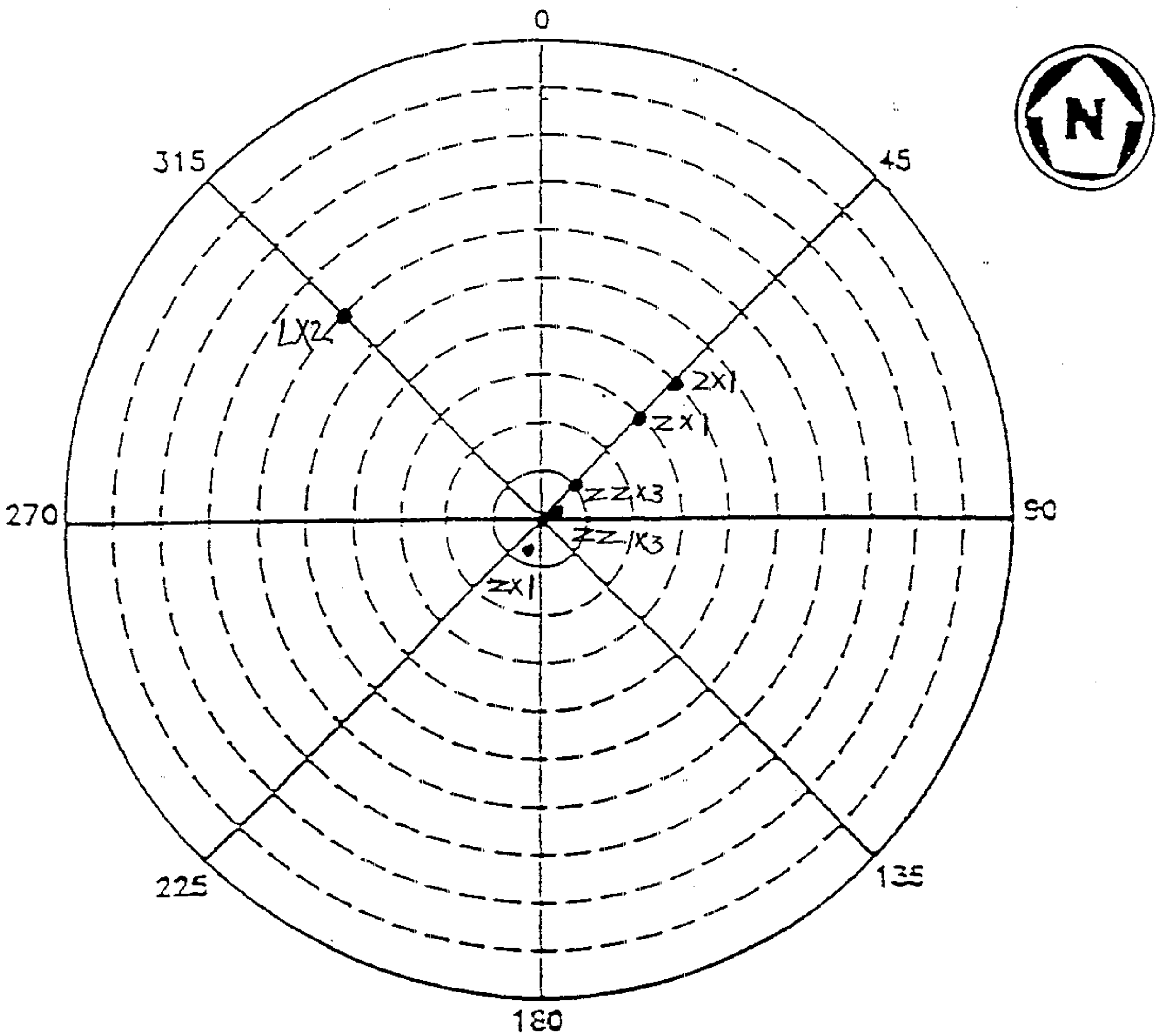
SIGNATURE: V. Watt

TABLE

BATTERY TYPE	QTY	CONDITION	
		#INTACT	#RUPTURED
ZINC(MERCURY)	3	3	
LEAD ACID			
TOTAL L & Z	3	3	

LEGEND
L=LEAD ACID BATTERY
Z=ZINC/MERCURY (PRIMARY)
S1=SAMPLE #1
A=ATON STRUCTURE

SITE PLAN



NOTES:

1 Locate every battery on the site plan with regard to the aid at the center.
2 Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan
3 Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature:

Aid Name: Moss Landing Hbr. Ent. Range Front Lt.
Aid # (LLNR): 4000
Position: LAT 36° 48 33.697 N
LON 121° 47 41.446 W
Date: 11-15-96

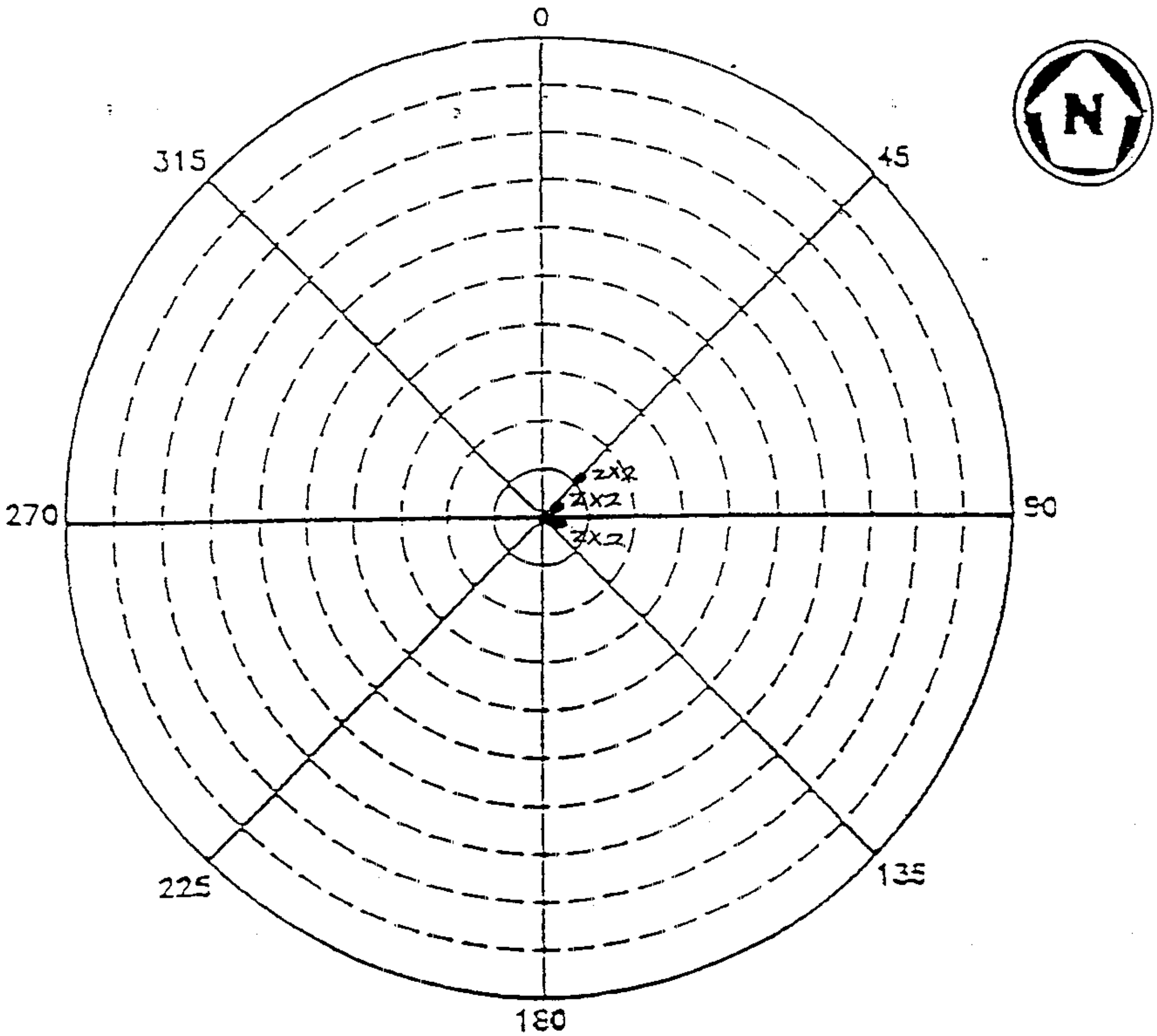
*NOTE: Circ. Search Extended 10'; No batteries found.

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid	2	2	
Zinc (Mercury)	9	9	
Total L & Z	11	11	

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

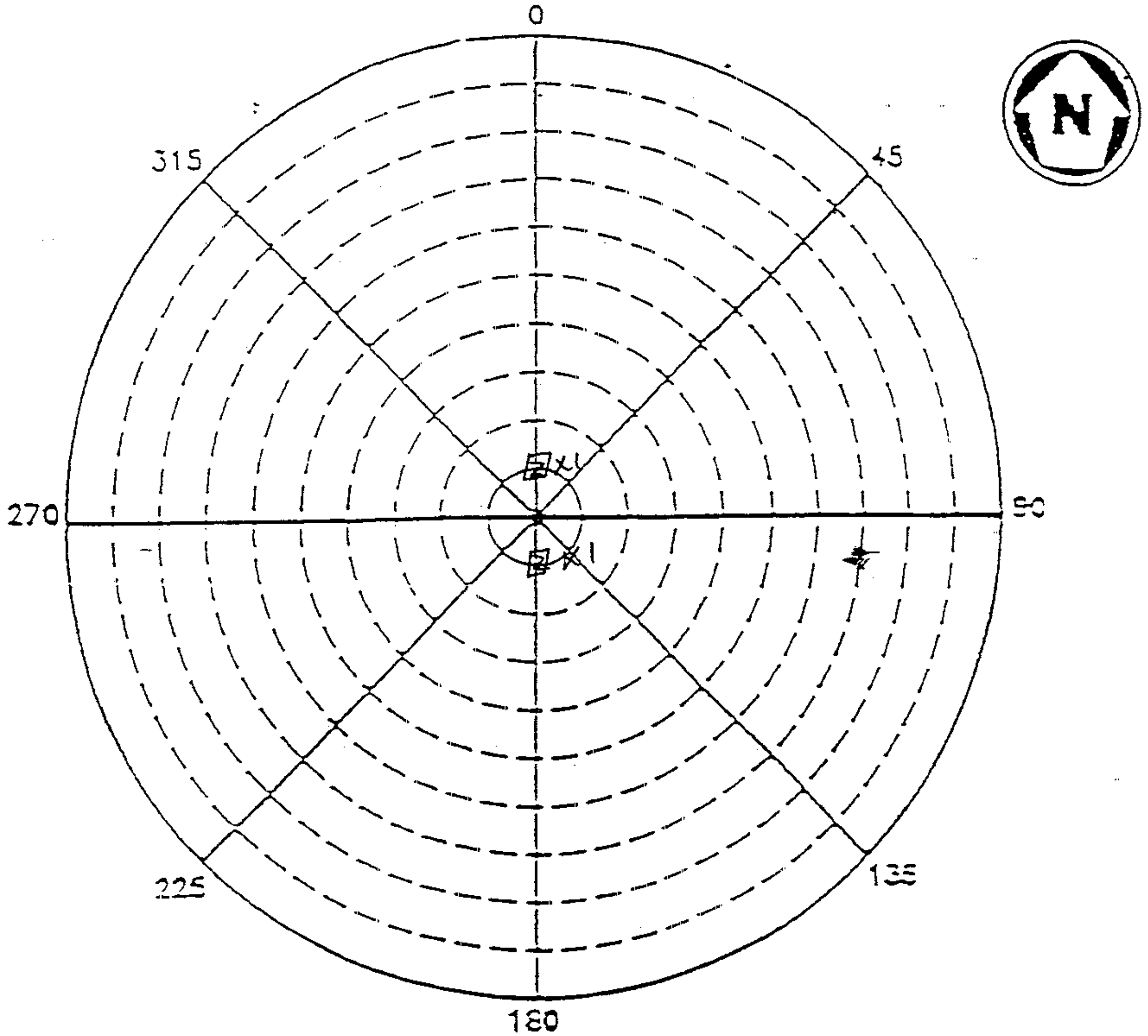
Aid Name: Moss Landing Hbr. Ent. Range Rear Lt.
Aid # (LLNR): 4005
Position: LAT 36° 48' 34.856 N
LON 121° 47' 22.857 W
Date: 11-15-96

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid			
Zinc (Mercury)	6	4	2
Total L & Z	6	4	2

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

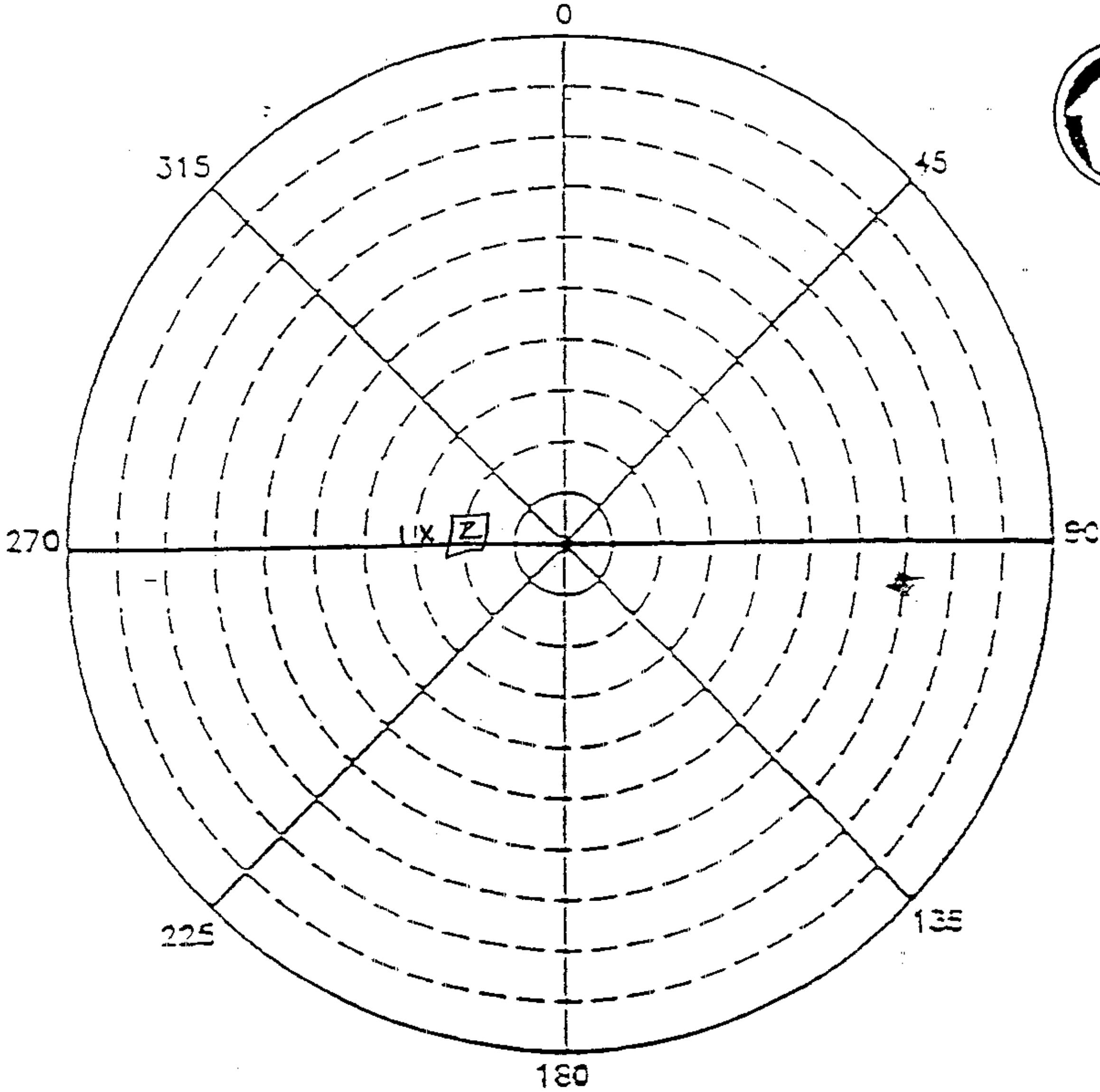
Aid Name: Petaluma Riv ENT. Lt. 2
Aid # (LLNR): 5980.
Position: LAT 38°02 56.673 N
LON 122°25 19314 W
Date: 12/23/96

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid			
Zinc (Mercury)	2		2
Total L & Z	2		2

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

SITE PLAN



OTES:

Locate every battery on the site plan with regard to the aid at the center.
Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
Circle ruptured batteries.
Draw a square around batteries that were removed.
In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature:

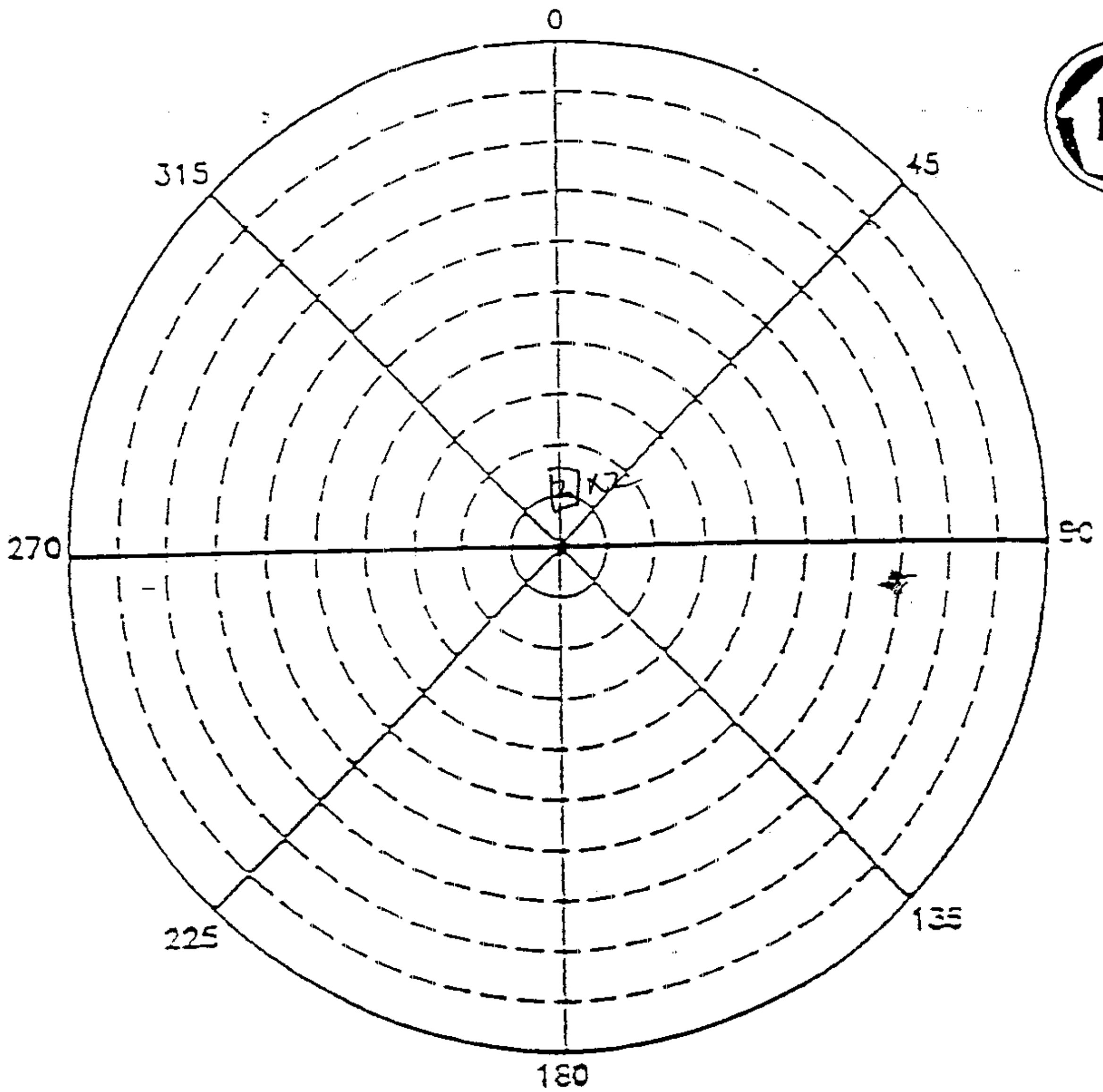
Aid Name: Petaluma Riv Ent Ch Lt 80
Aid # (LLNR): 6010.
Position: LAT 38° 05 20.530 N
LON 122° 26 29.452 W
Date: 12/23/96

ABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid			
Zinc (Mercury)	1		1
Total L & Z	1		1

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

Aid Name: Petaluma Riv Ent Ch Lt. 14

Aid # (LLNR): 6040.

Position: LAT 38° 06 18.110 N

LON 122° 27 16.805 W

Date: 12/23/96

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid	/	/	/
Zinc (Mercury)	2	/	2
Total L & Z	2	/	2

LEGEND

L = Lead Acid Battery

Z = Zinc Air Depolarized (Merc) Battery

LL = Lead Battery Group (3 or more)

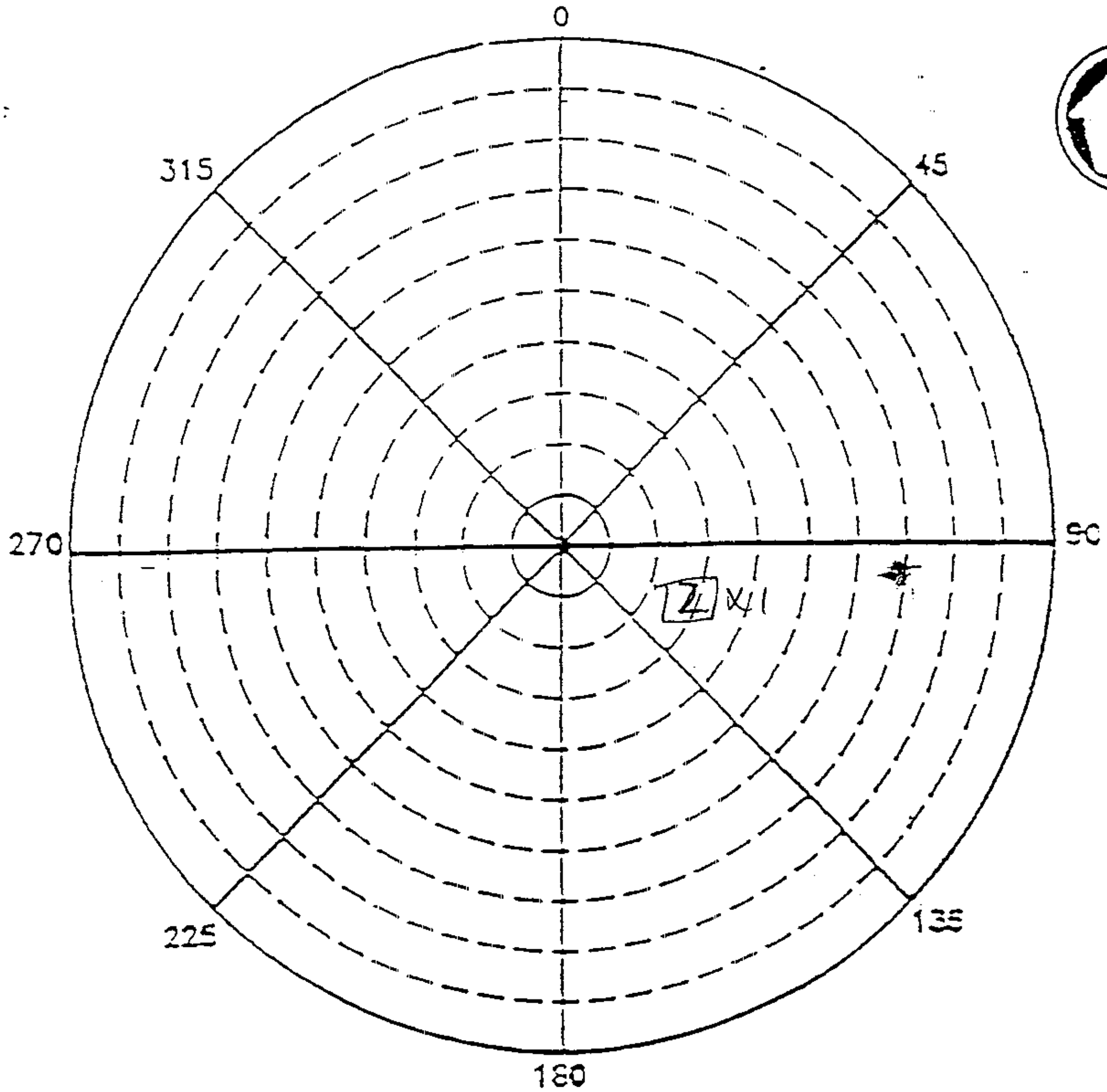
ZZ = Zinc Battery Group (3 or more)

LZ = Lead/Zinc Battery Group

P = Piling

S = Structure

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center.
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

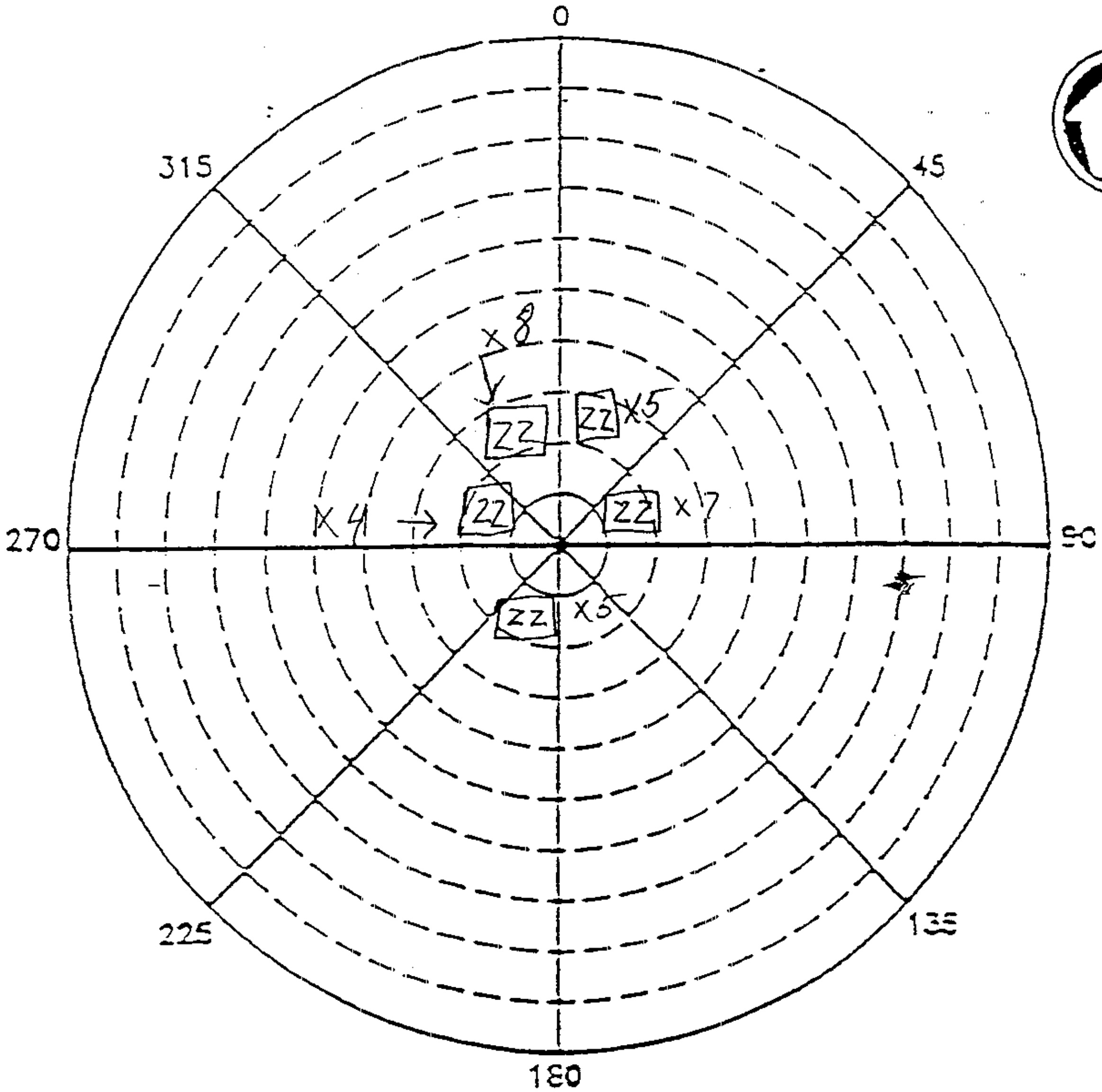
Aid Name: Napa Riv Lt. 18
Aid # (LLNR): 6205.
Position: LAT 38°14 47.022 N
LON 122°17 03.091 W
Date: 1-6-97

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid			
Zinc (Mercury)	1	Ø	1
Total L & Z	1	Ø	1

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center.
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature:

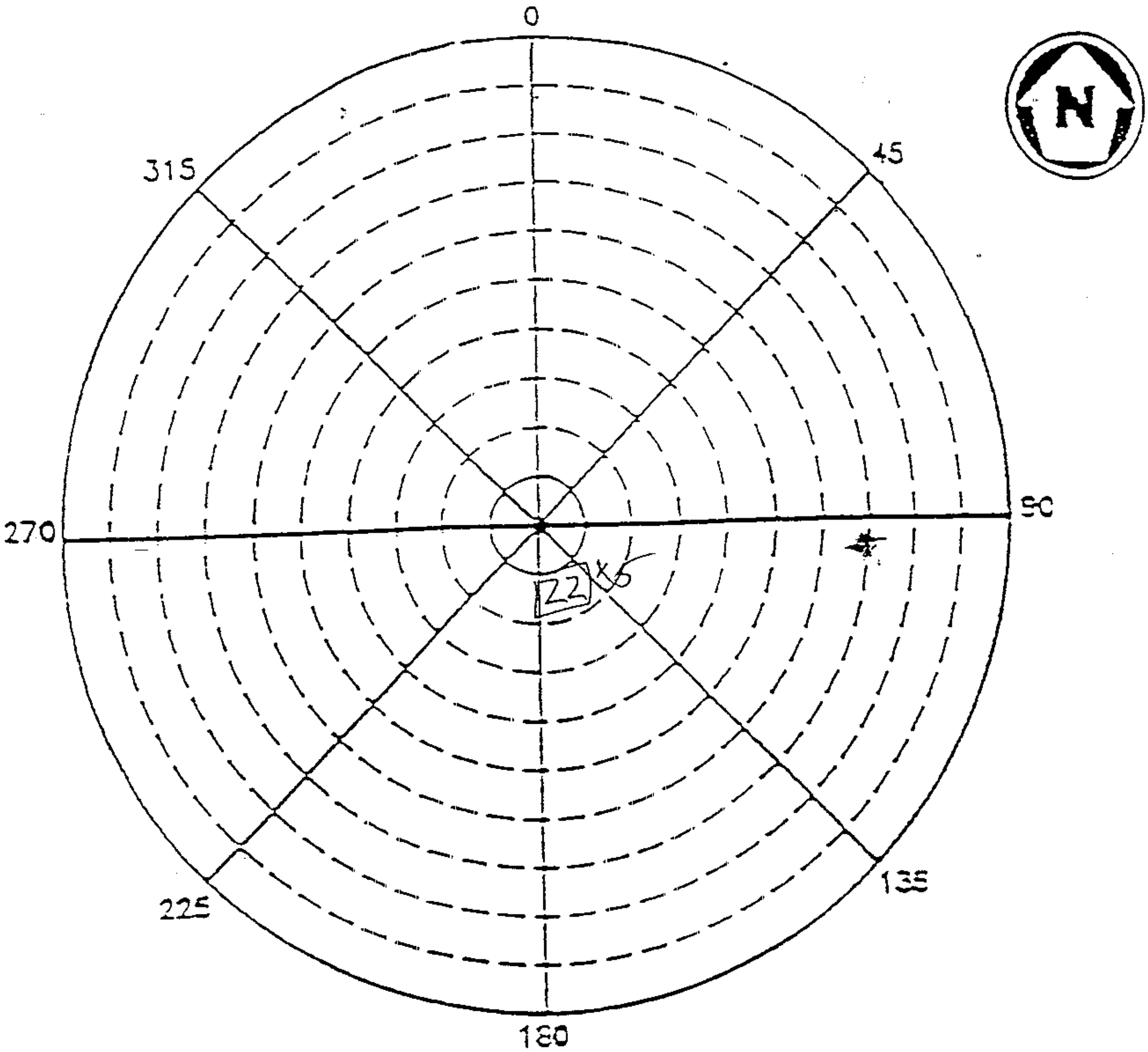
Aid Name: Napa Riv Lt 13
Aid # (LLNR): 6180.
Position: LAT 38° 11 32.898 N
LON 122° 18 51.315 W
Date: 1-6-97

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid			
Zinc (Mercury)	29	0	29
Total L & Z	29	0	29

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

SITE PLAN



OTES:

Locate every battery on the site plan with regard to the aid at the center.
Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
Circle ruptured batteries.
Draw a square around batteries that were removed.
In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature:

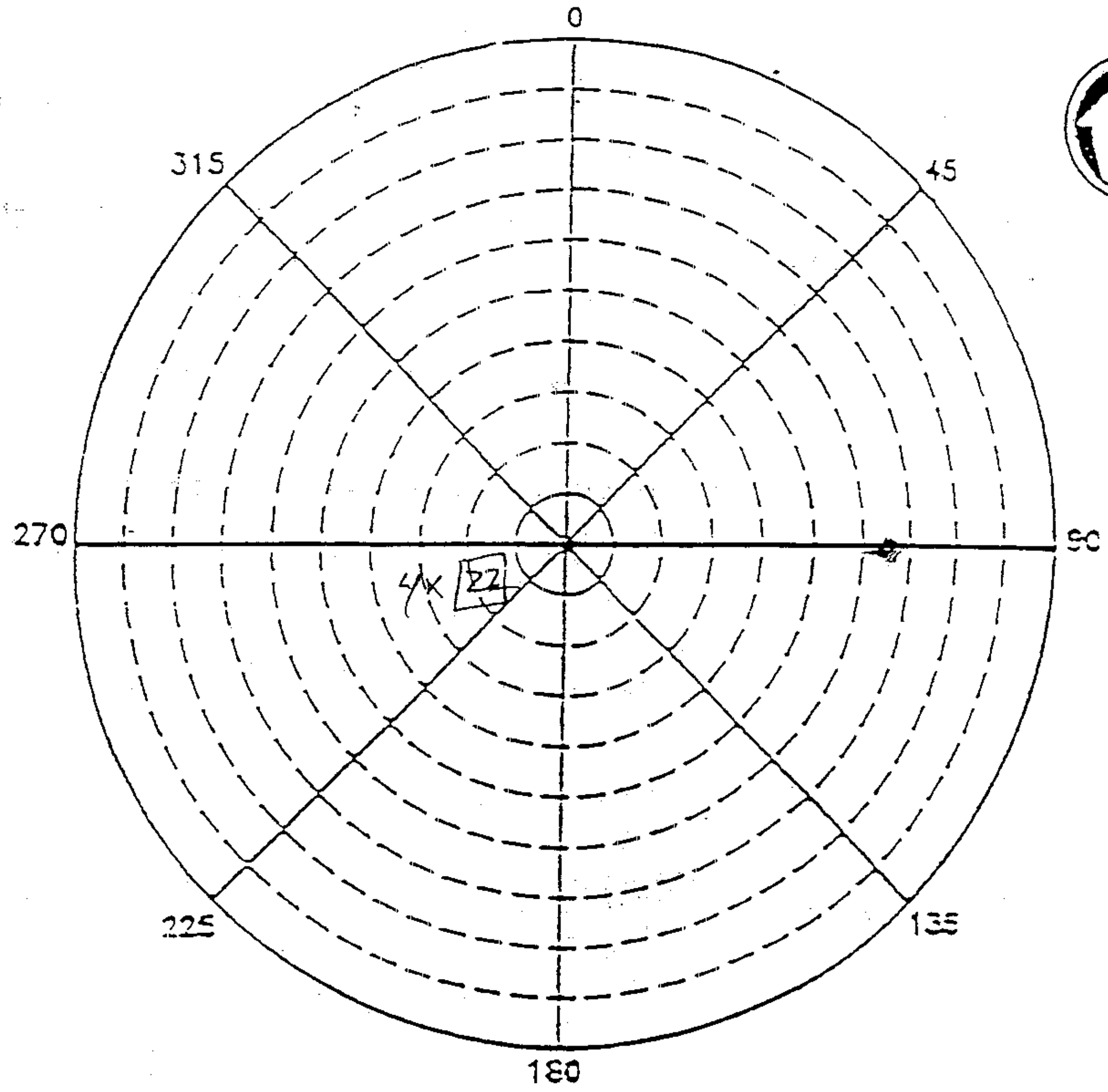
Aid Name: Suisun Slough Ent. Lt 10
Aid # (LLNR): 6350.
Position: LAT 38°07 08.624 N
LON 122°03 43.693 W
Date: 1-7-97

'ABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid			
Zinc (Mercury)	5	1	4
Total L & Z	5	1	4

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center.
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature:

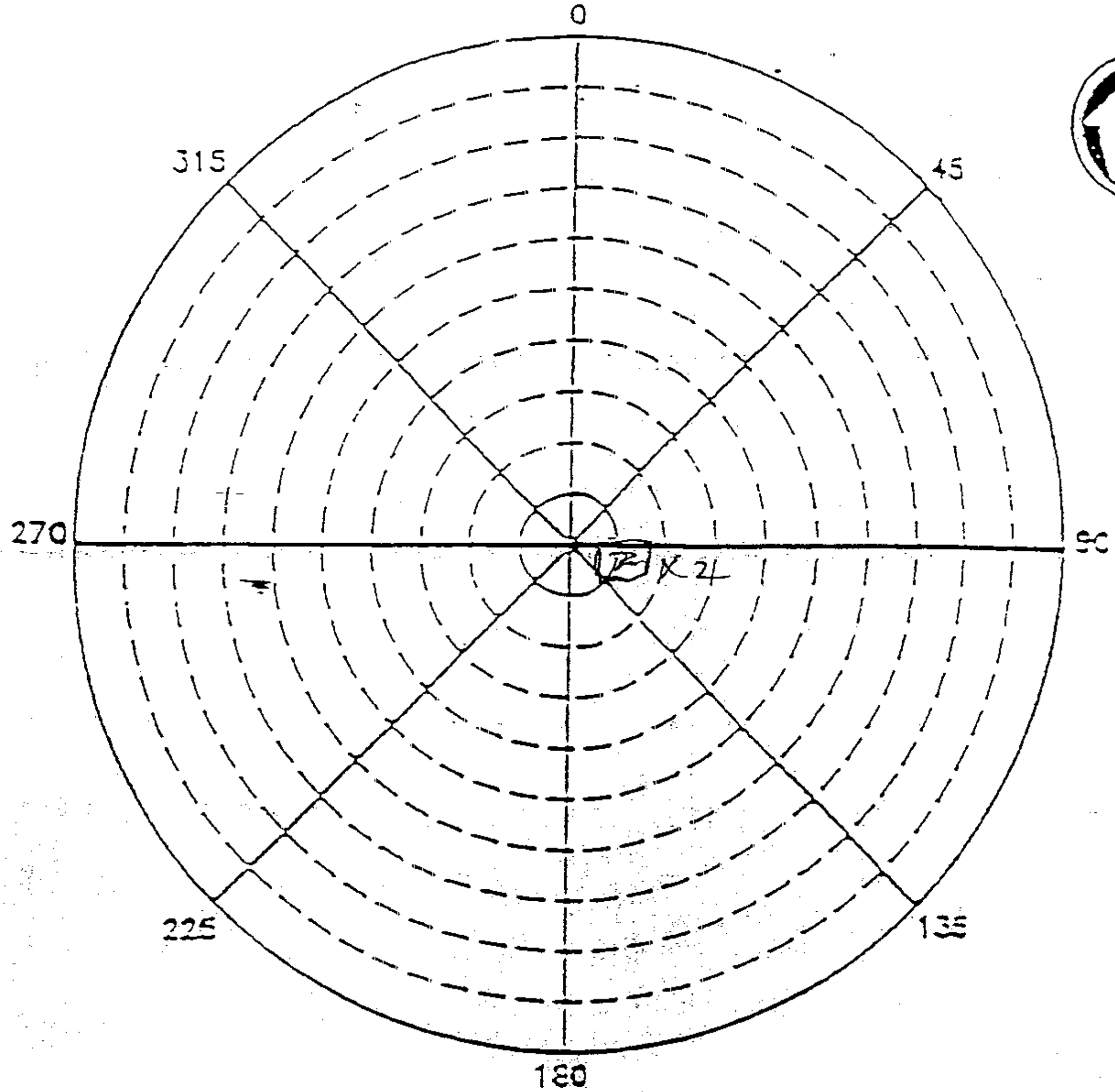
Aid Name: Stockton Ch Range E Rear Lt
Aid # (LLNR): 7010.
Position: LAT 38°01 21.375 N
LON 121°27 50.373 W
Date: 1-21-97

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid			
Zinc (Mercury)	4	4	
Total L & Z	4	4	

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

SITE PLAN



NOTES:

1. Locate every battery on the ~~site~~ plan with regard to the aid at the center
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries
4. Draw a square around batteries that were removed
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

Aid Name: Stockton Ch Lt 25

Aid # (LLNR): 7050.

Position: LAT 37 59 44.501 N

LON 121 26 21.850 W

Date: 1-23-97

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid			
Zinc (Mercury)	2	2	—
Total L & Z	2	2	—

LEGEND

L = Lead Acid Battery

Z = Zinc Air Depolarized (Merc) Battery

LL = Lead Battery Group (3 or more)

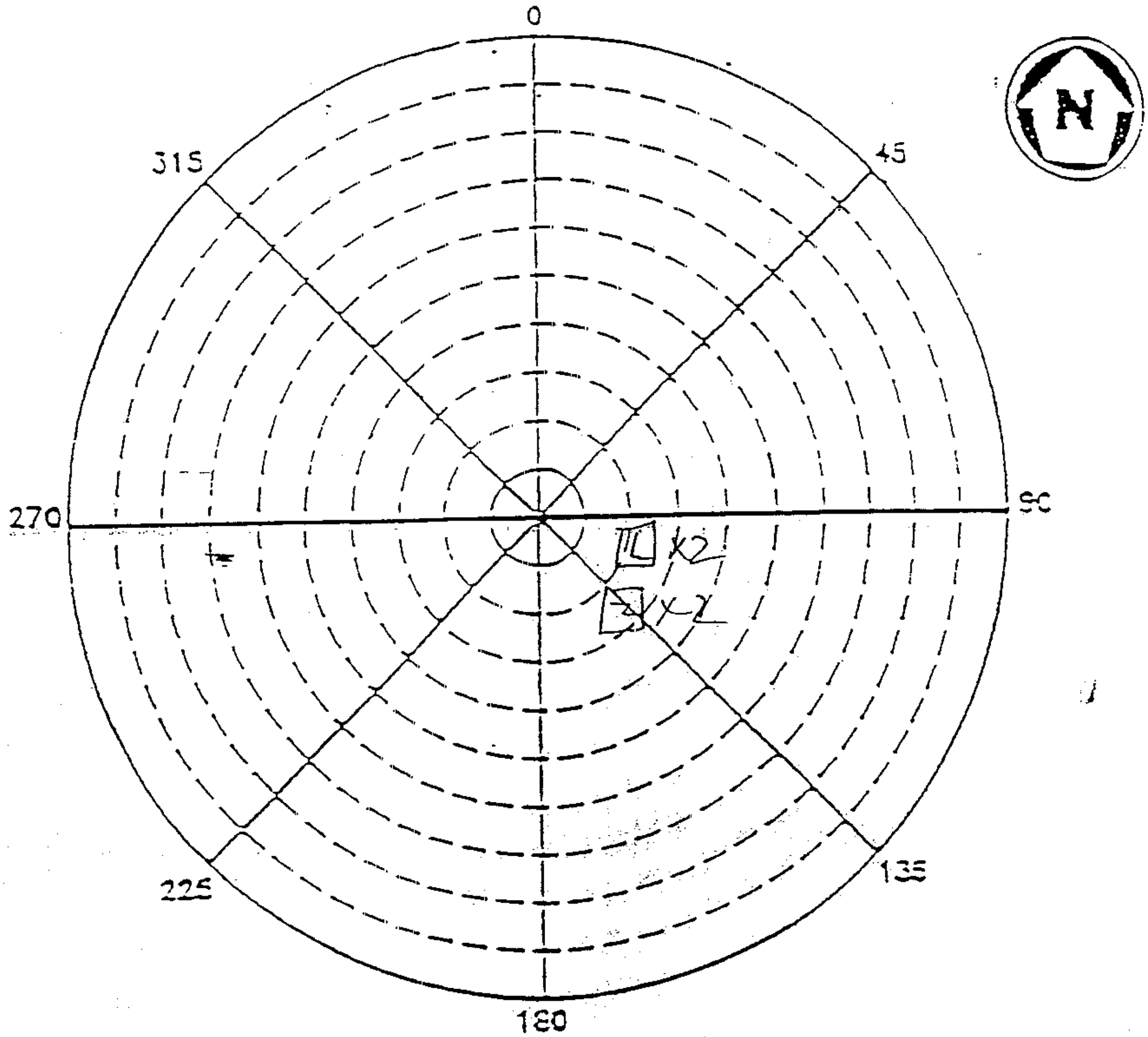
ZZ = Zinc Battery Group (3 or more)

LZ = Lead/Zinc Battery Group

P = Piling

S = Structure

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

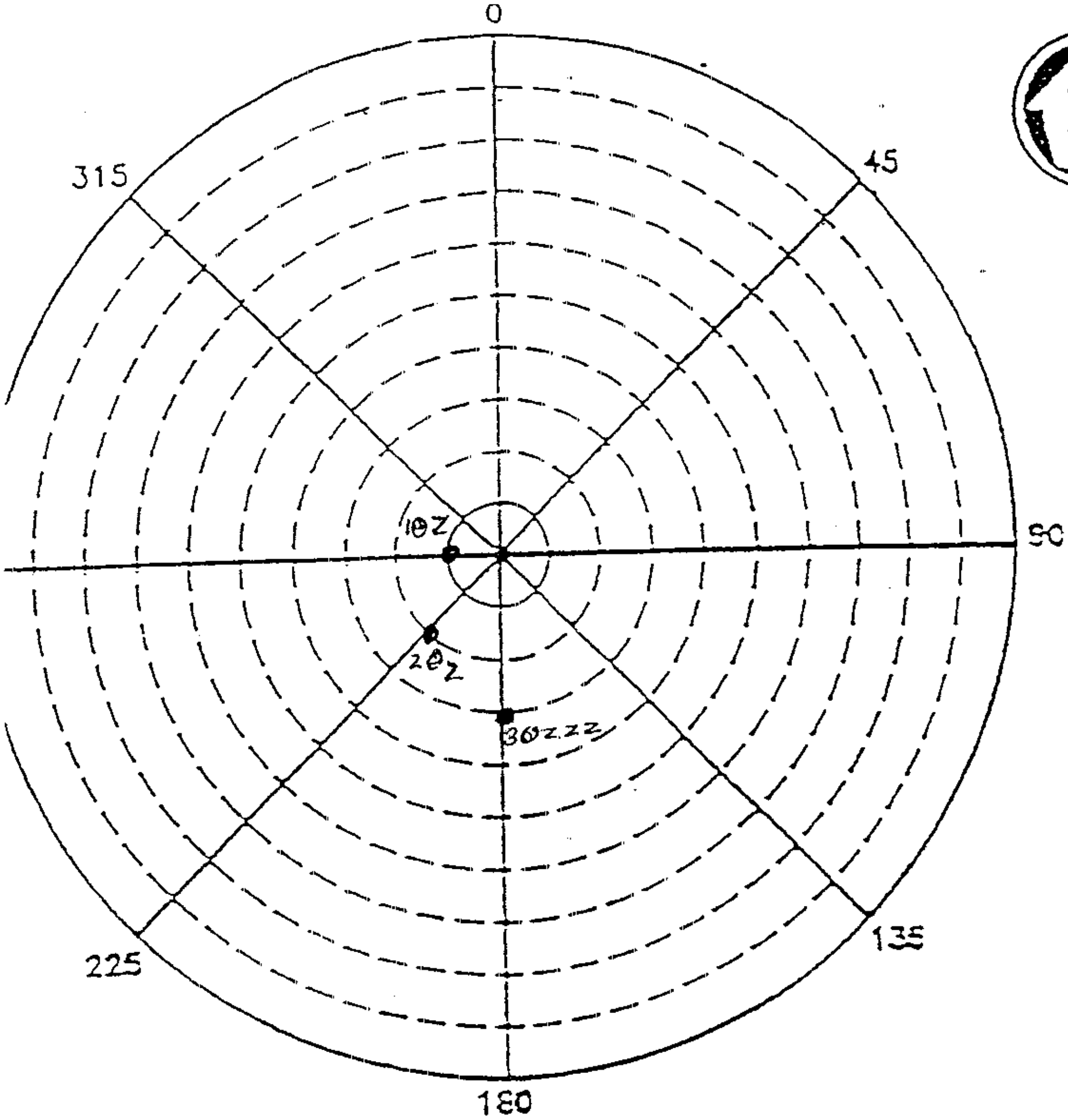
Signature: [signature]

Aid Name: Stockton Ch Lt 39
Aid # (LLNR): 7130
Position: LAT 37° 58 42.730N
LON 121° 22 54.638W
Date: 1-27-97

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid	2	2	—
Zinc (Mercury)	2	—	2
Total L & Z	4	2	2

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure



battery on the site plan with regard
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attery at each location on the site plan.
ed batteries.
re around batteries that were removed.
below, indicate the following: the
ach type of battery discovered; the
atteries; the # of ruptured batteries
and the respective totals.

Signature: [signature]

Aid Name: Bodega Hbr. Ch. Range C Front Lt. 14

Aid # (LLNR): 7845

Position: LAT 38° 18 47.396 N

LON 123° 03 07.967 W

Date: 11-19-96

	Qty	Condition	
		Intact	Ruptured
)	6	5	1
	6	5	1

LEGEND

L = Lead Acid Battery

Z = Zinc Air Depolarized (Merc) Battery

LL = Lead Battery Group (3 or more)

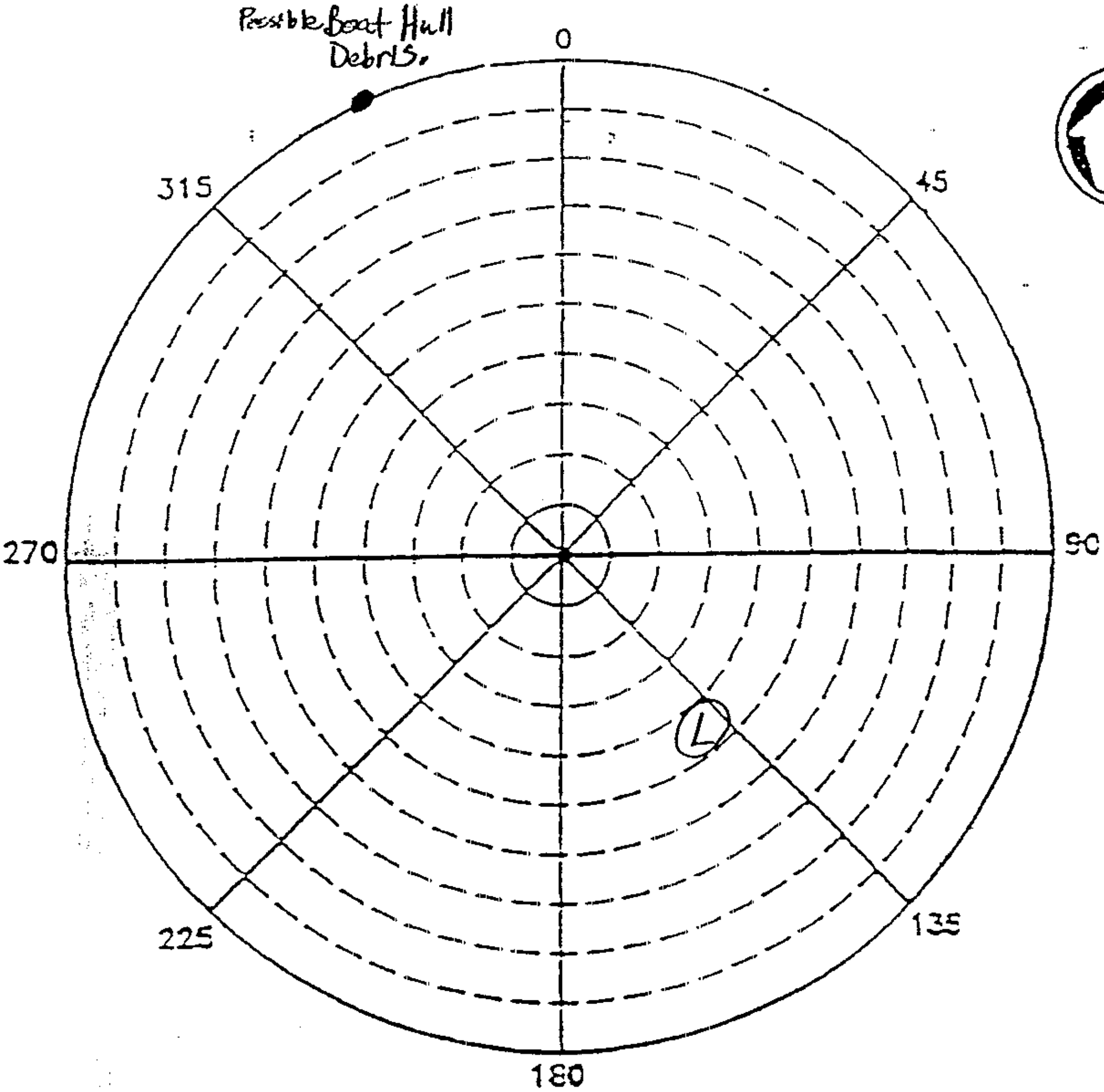
ZZ = Zinc Battery Group (3 or more)

LZ = Lead/Zinc Battery Group

P = Piling

S = Structure

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center.
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

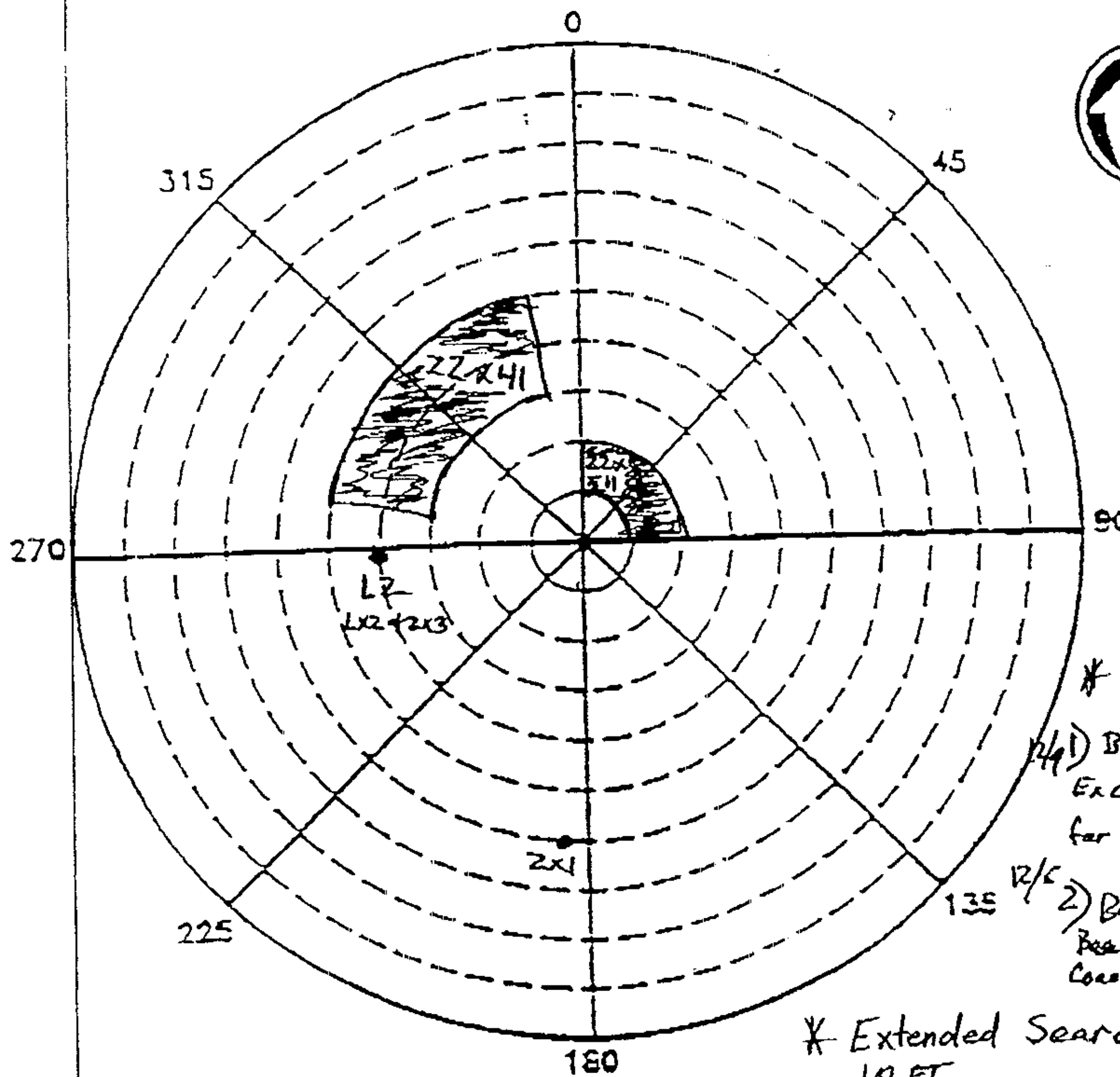
Signature:
Aid Name: Newport Bay Ch. Lt. 8
Aid # (LLNR): 2460.00
Position: LAT 33° 36 04.679 N
LON 117° 53 13.905 W
Date: 11-8-96

TABLE

Bat. Type	Qty	Condition	
'Delco'	1	Intact	Ruptured
Lead Acid	1	1	N/A
Zinc (Mercury)	N/A	N/A	N/A
Total L & Z	1	1	N/A

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

SITE PLAN



* 2 Dives Made

12/4 1) Battery Locating, Excavation, & Placement for Removal from Site

12/5 2) Battery Removal from Base of ATON into Coast Guards' Custody.

* Extended Search Diameter 10 FT.

NOTES:

1. Locate every battery on the site plan with regard to the aid at the center.
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

Aid Name: Richmond Hbr. App. Range Rear Lt.

Aid # (LLNR): 5675

Position: LAT 37°53 55.548 N

LON 122°23 19.591 W

Date: 12/4 + 12/5/96

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid	2	0	2
Zinc (Mercury)	56	3	53
Total L & Z	58	3	55

LEGEND

L = Lead Acid Battery

Z = Zinc Air Depolarized (Merc) Battery

LL = Lead Battery Group (3 or more)

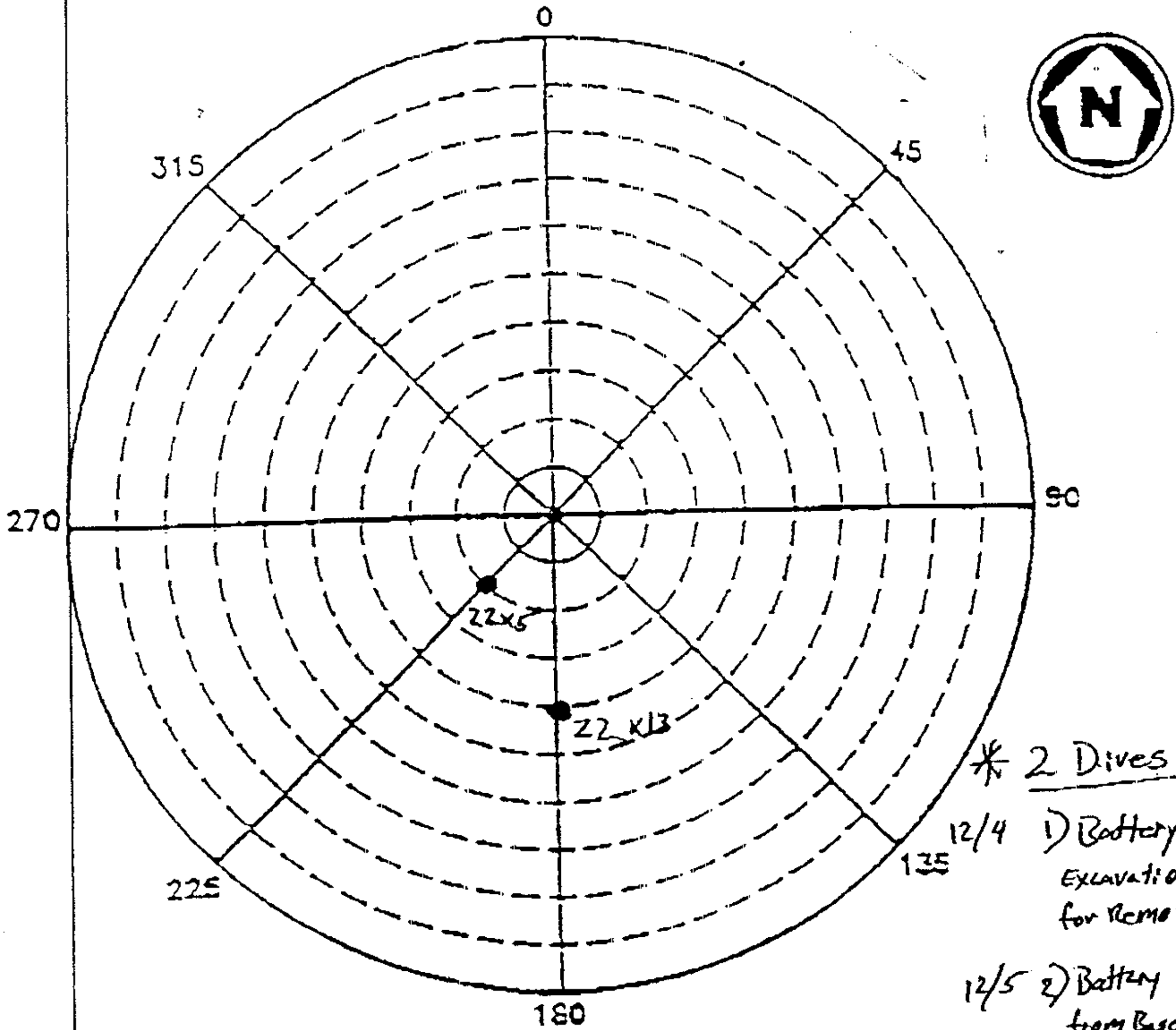
ZZ = Zinc Battery Group (3 or more)

LZ = Lead/Zinc Battery Group

P = Piling

S = Structure

SITE PLAN



* 2 Dives Made
12/4 1) Battery Locating Excavation, & Placement for Removal from Site
12/5 2) Battery Removal; from Base of ATON into Coast Guards' Custody.

NOTES:

1. Locate every battery on the site plan with regard to the aid at the center.
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

Aid Name: Richmond Hbr App Range Front Lt.
Aid # (LLNR): 5670.
Position: LAT 37° 54 02.489 N
LON 122°23 29.505 W
Date: 12/4 & 12/5/96

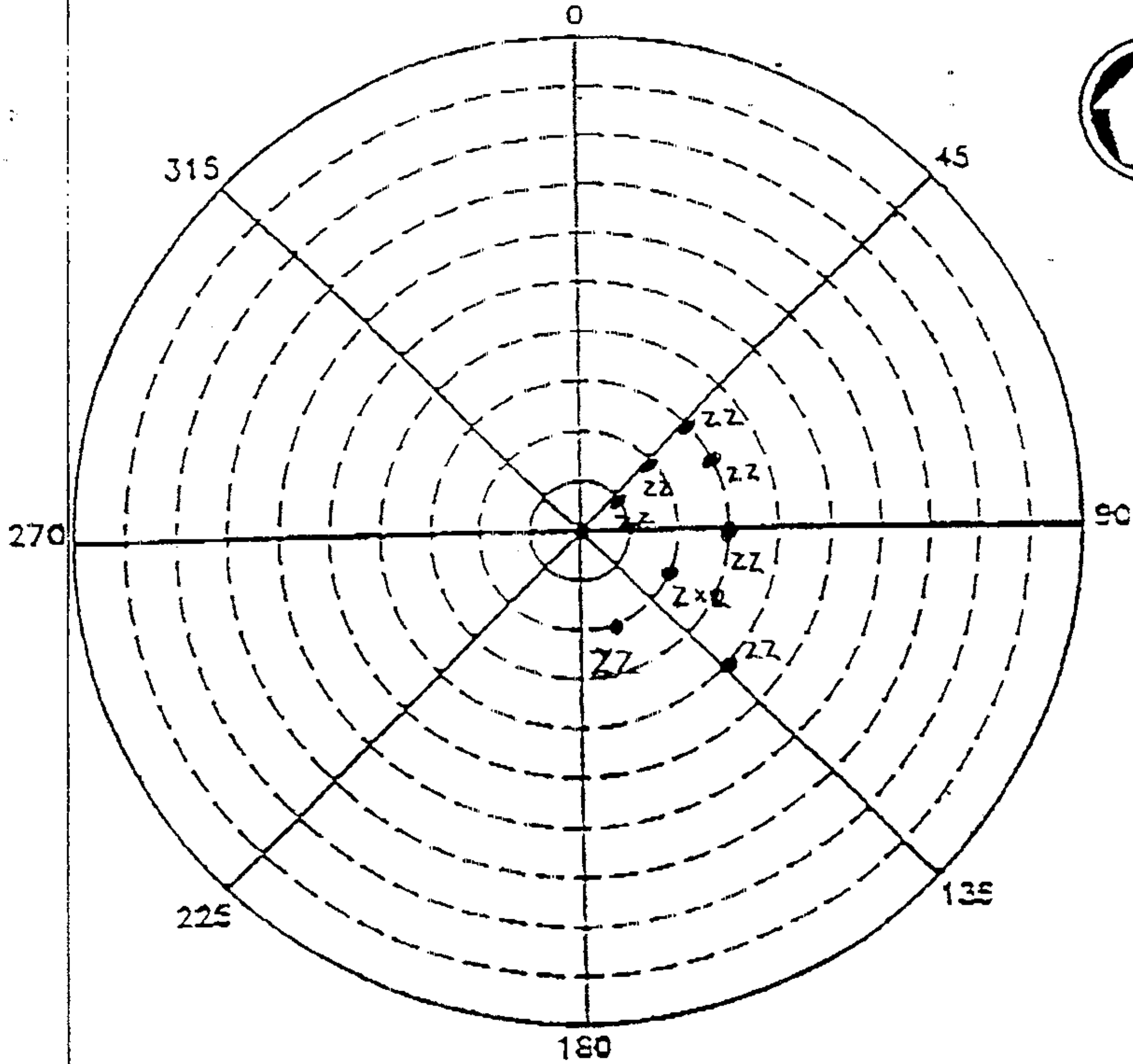
TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid	0		
Zinc (Mercury)	18	5	13
Total L & Z	18	5	13

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

8 of 12

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center.
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

Aid Name: Cone Rock Lt.

Aid # (LLNR): 4380

Position: LAT 37° 51 50.963 N

LON 122° 28 11.017 W

Date: 11-29-96

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid			
Zinc (Mercury)	23	1	1
Total L & Z	23	22	1

LEGEND

L = Lead Acid Battery

Z = Zinc Air Depolarized (Merc) Battery

LL = Lead Battery Group (3 or more)

ZZ = Zinc Battery Group (3 or more)

LZ = Lead/Zinc Battery Group

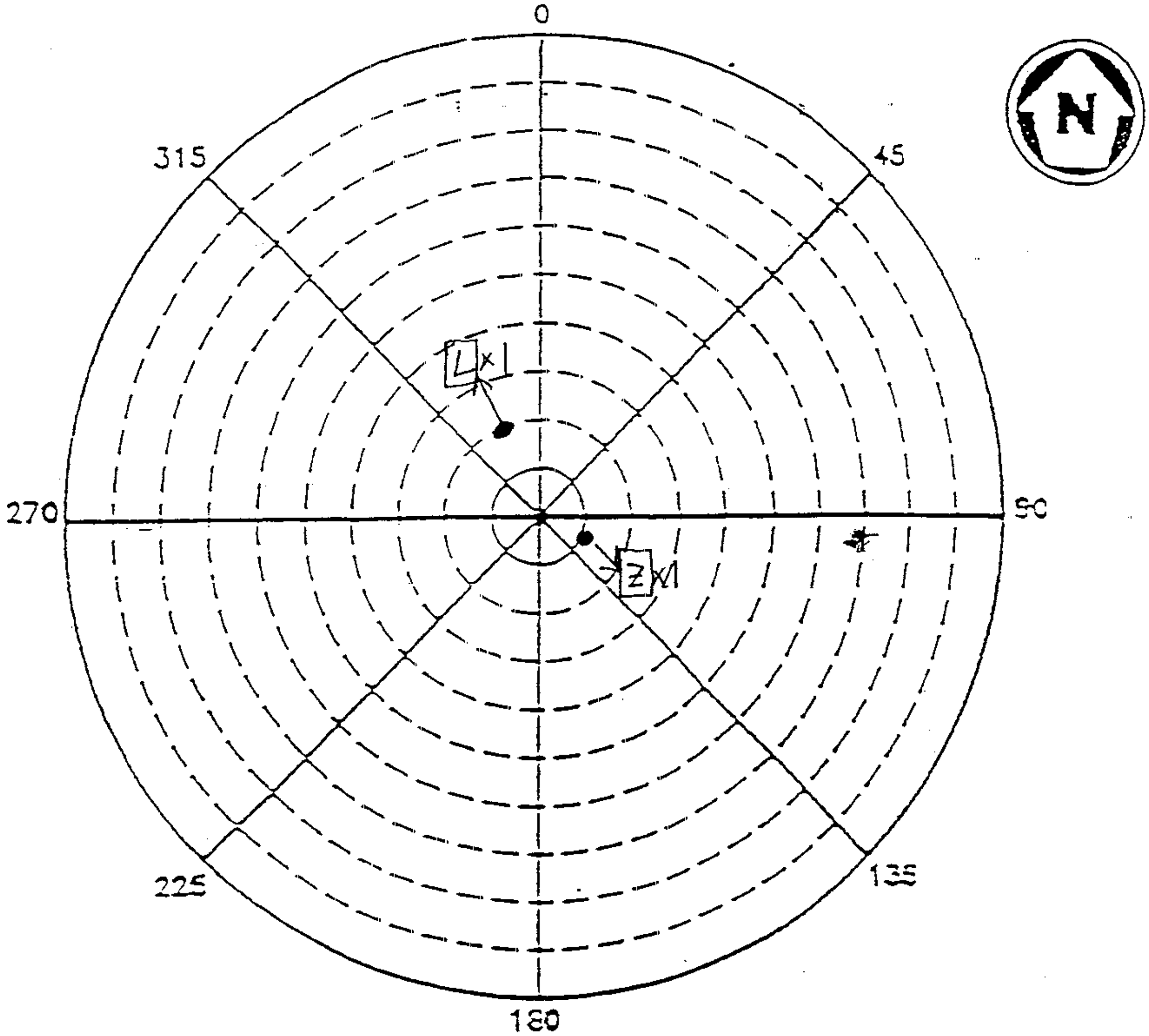
P = Piling

S = Structure

CORRECTED COPY
DESTROY PREVIOUS COPY

3 of 12

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center.
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan.
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

Aid Name: Redwood Cr. ENT. Lt. 4

Aid # (LLNR): 6790.

Position: LAT 37°32 49.449N

LON 122° 11 42.265W

Date: 12/18/96

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid	1	1	—
Zinc (Mercury)	1	1	—
Total L & Z	2	2	—

LEGEND

L = Lead Acid Battery

Z = Zinc Air Depolarized (Merc) Battery

LL = Lead Battery Group (3 or more)

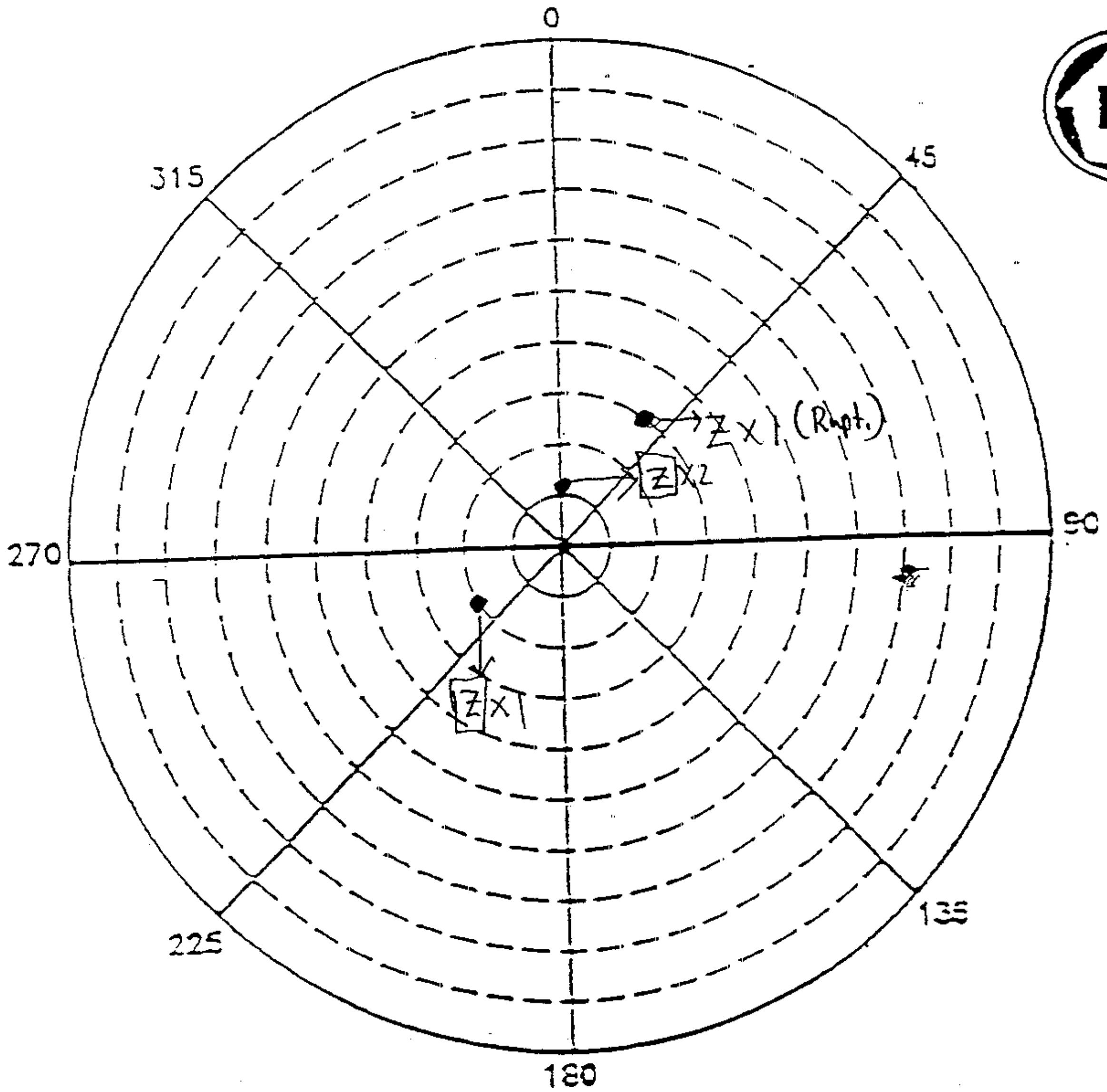
ZZ = Zinc Battery Group (3 or more)

LZ = Lead/Zinc Battery Group

P = Piling

S = Structure

SITE PLAN



NOTES:

1. Locate every battery on the site plan with regard to the aid at the center.
2. Use the symbols listed in the Legend to indicate the type of battery at each location on the site plan
3. Circle ruptured batteries.
4. Draw a square around batteries that were removed.
5. In the table below, indicate the following: the quantity of each type of battery discovered; the # of intact batteries; the # of ruptured batteries discovered; and the respective totals.

Signature: [signature]

Aid Name: Redwood Cr. Lt. 15
Aid # (LLNR): 5245
Position: LAT 37° 31 03.404 N
LON 122° 12 23.708 W
Date: 12/16/96

TABLE

Bat. Type	Qty	Condition	
		Intact	Ruptured
Lead Acid	0		
Zinc (Mercury)	4	3	1
Total L & Z	4	3	1

LEGEND
L = Lead Acid Battery
Z = Zinc Air Depolarized (Merc) Battery
LL = Lead Battery Group (3 or more)
ZZ = Zinc Battery Group (3 or more)
LZ = Lead/Zinc Battery Group
P = Piling
S = Structure

APPENDIX B

U.S. Department
of Transportation

**United States
Coast Guard**

Commandant (G-ECV-1)
United States Coast Guard

MAILING ADDRESS:
Washington, DC 20593-0001
(202) 267-1924

16500

GS
X [illegible] (A)(c)
end
Impacts?

From: Commandant
To: Distribution

Subj: MIT STUDY OF MERCURY FROM PRIMARY ATON BATTERIES

1. Enclosure (1) is a copy of the recent preliminary study of mercury from ATON batteries performed by the Massachusetts Institute of Technology (MIT), under contract to the Volpe National Transportation Systems Center. This study is forwarded for your information and distribution (as needed).

2. Enclosure (2) is a Media Advisory released 22 Mar 94 highlighting the report's conclusions and summarizing ATON battery recovery efforts to date. The POC for questions is LTJG Michael Bee, G-ECV-1A, (202) 267-1926.

Rebecca Patton

REBECCA PATTON
By direction

Encl: (1) MIT ATON Battery Study
(2) G-CP-2 Media Advisory of 22 Mar 94 re: ATON Batteries

Dist: G-NSR
G-NIO
G-CP (w/o Enclosure (2))
MLCLANT(s)
MLCPAC(s)
All District (oan)
All CEU's

The Fate of Mercury from AtoN Batteries
A report to the Volpe Center
Attn: Sherry Borener

François Morel & Rob Mason
R.M. Parsons Laboratory, MIT

Background: 1. Mercury in AtoNs

Aids to navigation - AtoNs - consisting of fixed lights and lighted buoys used to be powered by primary batteries, until replacement by solar cells in 1983. Up to 1973, these batteries were routinely discarded on-site. The discovery of such discarded batteries by divers has recently brought the subject to public attention. Besides the outcry, the important questions are what public health or environmental hazards may be posed by these batteries, and what should now be done with them.

According to a study performed by WAPORA in 1981, the batteries may be considered hazardous waste because of their highly alkaline pH (pH $\simeq$ 14) and their mercury content which sometimes exceed the maximum allowable concentration of 0.2 mg L^{-1}. Since the high pH of the battery material poses no danger in the aquatic environment (the alkaline solution will either remain contained or be neutralized upon dilution in the water) it is the mercury content of the batteries that is of concern.

In this report we examine the fate of the mercury from AtoNs and assess its environmental impact.

Background: 2. Mercury in the Environment

Mercury exists in the environment in three principal forms:

- elemental mercury, Hg(0), a familiar liquid which has a solubility limit of ca 70 μg L^{-1} in water, and is readily volatilized as a gas.

The corresponding cathodic reaction usually involves the reduction of atmospheric oxygen. Mercury is employed in the fabrication of the battery "to reduce the corrosion of the zinc anode". Clearly, the goal is not to prevent the necessary oxidation of the metallic zinc, but rather to make it occur smoothly. The role of mercury may thus be represented as surface catalysis in which oxidation of the metallic mercury which coats the surface

$$Hg^{\circ} \rightarrow Hg^{2+} + 2e^{-}$$

is followed by reduction of the Hg(II) and even oxidation of the metallic zinc at the surface:

$$Hg^{2+} + Zn^{\circ} \rightarrow Hg^{\circ} + Zn^{2+}$$

This reaction is extremely favorable energetically (Δ G° = −312 KJ) such that Hg(II) should be readily reduced to Hg(0) by metallic zinc. Thus, as long as there is some part of the zinc anode left in the battery we can expect the mercury to be present almost entirely as elemental Hg. In other words, during the useful life of the battery, Hg remains mostly as Hg(0). This is indeed what we have found in our laboratory studies. As discussed in Appendix 2, the mercury content of batteries discarded to the water was all as elemental mercury, while a few percent of the mercury in a depleted battery, that was not disposed of in water, was oxidized ionic mercury.

<u>Loss of Mercury from AtoNs Prior to Disposal</u>

In unsealed batteries (which are often designed to be vented) elemental mercury has ample opportunity to be lost to the atmosphere as Hg(0) vapor during use. This volatilization should be particularly effective toward the end of the life of the battery when much of the Zn anode has been corroded away. Clearly the percentage of mercury that is lost in this way will be highly variable, depending on the design of the battery and on the replacement cycle. As seen in Table 1, WAPORA analyzed one unused battery and we analyzed one used battery that had not been discarded, and three batteries removed from the sea floor. The unused battery had the expected mercury content of ca 20 g Hg, the used/undiscarded battery had about half that much (10 g Hg) and the discarded batteries only 1 - 10 % of the original value (0.1 - 2 g Hg). The difference between these results

There is no information on the possible rate of oxidation of mercury under these conditions but it is likely to be very slow particularly since all foreign materials in natural waters become rapidly coated by a reducing film of natural organic matter and since the general tendency is for mercury in surface water to be reduced, not oxidized (see above). We can thus assume that the oxidation rate of elemental mercury is negligible and that the principal mode of release of mercury from the AtoN batteries is through simple dissolution of Hg(0).

Dissolution Rate of Elemental Mercury. The rate of dissolution of elemental mercury from AtoNs is the key parameter we need to estimate in order to predict the environmental consequences of the AtoNs. We can estimate this rate on the basis or either theoretical calculations or laboratory experiments; we can also verify from the available field data that our estimates are reasonable.

The theoretical calculations are based on the observation that the kinetics of dissolution are severely limited by the very low solubility of Hg(0) in water which guarantees that the process is diffusion controlled. The parameters that control the dissolution rate are then fixed by the geometry of the exposed mercury and the mixing regime in the water. The chemistry of the system has no influence on the process and the dissolution of elemental mercury should proceed at similar rates in saline and fresh waters and in oxic and anoxic sediments. As seen in Table 2, we calculate an average net dissolution rate of Hg(0) on the order of 40 μg per day per gram of mercury in the battery. This corresponds to a half-life (the time it takes for half of the mercury to be dissolved) of about 47 years. Actual half-lives may be as short as a few years for broken batteries in highly mixed tidal zones or as long as a few hundred years in very quiescent waters. A dissolution kinetics experiment with one opened cell of a Saft battery in a 10L bath released 70 ng/L in one hour. The corresponding dissolution rate of 17μg per day per 0.78 g of Hg is somewhat slower than the calculated value of 40 μg per gram per day. The corresponding half-life is about 86 years, somewhat longer than the calculated median value.

Local Environmental Impact of Mercury from AtoNs

The elemental mercury that is released into the water will become involved in the natural cycle of mercury. The question then is what will be the increase in the local concentration of mercury and the resulting impact on the aquatic biota.

Increased Concentrations in the Water Column. Since very little if any of the elemental mercury released from the batteries is likely to be oxidized and even a smaller fraction to be methylated (again, Hg(0) is not directly methylated) we expect that it will simply augment the flux of elemental mercury that is being released to the atmosphere and originates naturally from reduction in the water column. Typical input and output rates from mercury in a (relatively) pristine site are on the order of 30 ng per meter square per day. Thus the natural atmospheric input to a 10^4 m^2 body of water (approximately only 300' × 300') would be 300 μg/day, equivalent to the total dissolution from 7.5 broken batteries (each leaking mercury at 40μg/day). Thus the elemental mercury concentration in the water may in some cases be increased significantly by the battery release: according to the calculations in Tables 3 and 4 the increase in elemental mercury due to the batteries may be as high as the natural Hg(0) concentration (0.1-0.2 ng L^{-1}). While this increase may be measurable, it would be well within natural variations and correspond to only a small fraction of the total mercury concentration in the water which is relatively high – up to 4 ng L^{-1} in inland and coastal waters.

Increased Concentrations in the Sediments. In the sediments, we expect the concentration of mercury to be affected in a very non-uniform fashion. The physical breakdown and dispersion of the battery content should result in a spotty distribution of the mercury, such that, while most sediments samples should remain at background levels, a few samples should reveal very high concentrations. As argued above, this high mercury concentration in the sediments, which represents small pools of elemental mercury, could remain for up to a few hundred years. This is indeed what has been observed for example in the study conducted by D. Merkel in the St. Marys River: most samples were below the detection limit of 0.1 ppm, but a few (8) samples were measured in the 5-100 ppm range.

On a global basis we can compare the release from the 10,000 AtoNs in the whole country to other global emissions. We estimate the actual total mercury release from AtoNs at 0.03 tons per year. This can be compared with a **natural** global emission rate of 1,600 tons per year and an anthropogenic flux of 4,000 tons per year. Again, if we assumed that all the some 2 million batteries ever used in AtoNs were brand new and released all their mercury in one year the total release would only be 60 tons, a minuscule fraction of yearly emissions.

Conclusions

The mercury contained in AtoNs is principally elemental mercury. It can be released by volatilization to the atmosphere prior to disposal and by dissolution to the water thereafter. The mercury content of a battery at the time of its disposal depends on its type and may vary from half its original content (10 g) for some gel batteries, to a fraction of that (1-2 g) for others. Discarded, but intact, batteries release their content to the environment at a negligible rate. At the time of disposal the few percent of mercury that was in ionic form would have dissolved rapidly from broken batteries. In contrast the bulk of the mercury which is in elemental form is being slowly released by dissolution into the ambient water with a typical half-life on the order of 30-100 years. This mercury augments the natural rate of cycling of elemental mercury in the local water body and ends up volatilized into the atmosphere. It is expected that none of it should be oxidized or methylated or become accumulated by the planktonic biota. While mercury release from the batteries would, at the most, result in a few percent increase in **total** mercury concentration, it may in some cases cause a significant increase in **elemental** mercury concentration in the ambient water. While measurable in principle, this increase would be impossible to document since it is within the normal variations observed in natural waters and no "control" measurements are available. Because elemental mercury is not oxidized or accumulated by the biota, we expect to see no measurable biological effects due to the AtoNs, either in the local sediments or in the water column. Any possible effect would have been maximum at the time of disposal 20 to 40 years ago. On a regional and global

Table 1

WAPORA Extracts:	Unused gel battery Spent gel batteries	Hg = 0.63 mg/L Hg = 0.06 & 0.09 mg/L
Our analysis of total mercury content in old batteries:	Liquid Alkali batteries Gel Alkali battery	Hg = 0.05 & 0.1 g Hg = 1-2 g
Reported content of new batteries:	Cegasa Edison	Hg = 20 g Hg = 18 - 21 g

Table 3

Volatilization Rate of Elemental Mercury

Because surface waters are very much supersaturated in Hg(0) compared to the atomosphere, the volatilization rate, V, through a surface area A' at the water surface, can be simply written as proportional to the concentration of Hg(0) in the water:

$$V = \frac{D}{\delta'} \cdot A'[Hg(0)]$$

The ratio of $\frac{D}{\delta'}$ (where D is the diffusion coefficient of Hg(0) and δ' is the thickness of the surface boundary layer) is known as a "piston velocity". It characterizes the mixing regime at the water surface and is mostly a function of wind speed. A typical range is

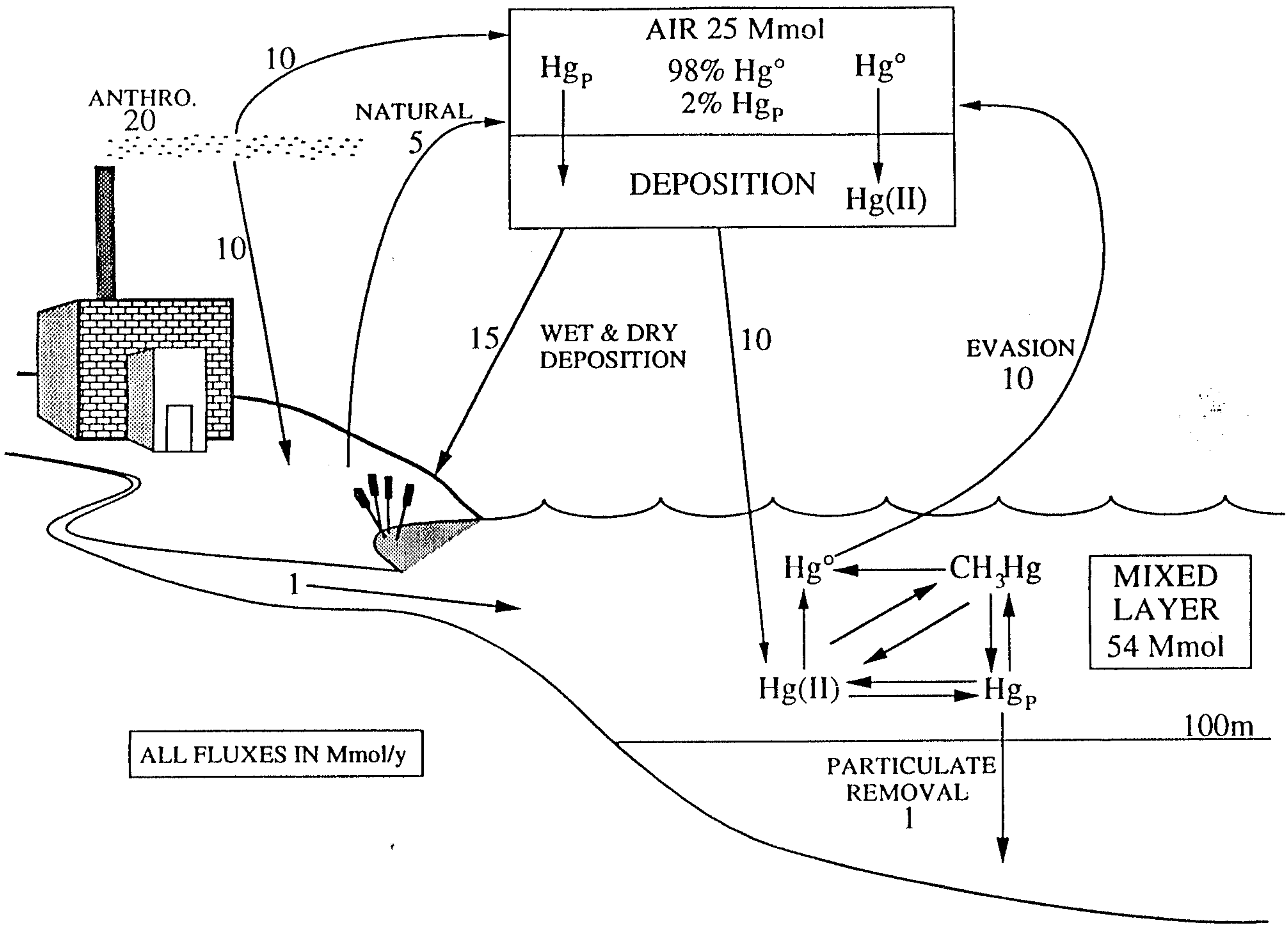
$$\frac{D}{\delta'} = 1 - 10\text{m d}^{-1}$$

Choosing a mid range value of 3 m d^{-1}, we can calculate, for example, the increased steady state concentration of elemental mercury, Δ[Hg(0)], resulting from 50 broken batteries, each leaking mercury at 40 μg d^{-1}, in a body of water venting through a surface area of 10^4 m^2. When the input from the batteries is equal to the output from volatilization:

$$\Delta[\text{Hg}(0)] = \frac{V \cdot \delta'}{D \cdot A'} = \frac{2000\mu\text{gd}^{-1}}{3\text{m d}^{-1} \times 10^4 \text{ m}^2}$$
$$\Delta\text{Hg}(0)] = 6 \times 10^{-2}\mu\text{g m}^{-3} = 60\text{pg L}^{-1}$$

This increase in concentration would lead to a sizeable increase in the typical elemental mercury concentration in coastal waters (100 - 200 pg L^{-1}). The resulting value would be well within the normal spatial and temporal variations that are observed, however, and could thus not be documented (even if these concentrations are now measurable by a handful of researchers). This increase in mercury concentration in the water column would also only be a small fraction (about 2%) of the total mercury.

value of the ratio of 10^{-7} [A = 10 cm^2; A' = 10^4 m^2] leads to an increase in elemental mercury concentration Δ [Hg(0)] = 7 $\times 10^{-12}$ g L^{-1} = 7 pg L^{-1} per g of Hg(0) in broken batteries. This calculation which is more conservative than that of Table 3 shows that even in quiescent waters the increase in elemental mercury concentration due to the batteries would not exceed a few hundred pg L^{-1}, only a small fraction of the total mercury in the water.



AIR 25 Mmol
Hg_p
98% Hg^o
2% Hg_p
Hg^o
DEPOSITION
Hg(II)
ANTHRO.
20
NATURAL
5
10
10
15
WET & DRY
DEPOSITION
10
EVASION
10
Hg^o
CH_3Hg
Hg(II)
Hg_p
MIXED
LAYER
54 Mmol
100m
1
PARTICULATE
REMOVAL
1
ALL FLUXES IN Mmol/y

Fig. 1

REFERENCES

R.P. MASON, W.F. FITZGERALD AND F.M.M. MOREL (in press) The biogeochemical cycling of elemental mercury: Anthropogenic influences. Geochimica et Cosmochimica Acta (in press).

J.O. NRIAGU (1991) Worldwide contamination of the atmosphere with toxic metals. In Proceedings of Trace Metal Symposium, NADP, October 1991

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UNITED STATES COAST GUARD
Headquarters Public Affairs
Division Chief: Capt. Ernest Blanchard
202-267- 1587

MEDIA ADVISORY DATE: MARCH 22, 1994

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RESEARCH FINDINGS INDICATE COAST GUARD AID TO NAVIGATION (AToN) BATTERIES NOT HAZARDOUS TO MARINE ENVIRONMENT

MIT RESEARCH FINDINGS

The Volpe National Transportation Systems Center in Cambridge, MA released initial research findings today concluding that the mercury and alkaline solution contained in spent Coast Guard AToN batteries are unlikely to harm the marine environment or enter the food chain.

The study, performed by Massachusetts Institute of Technology (MIT) researchers Professor Francois Morel and Dr. Robert Mason, examined whether mercury, small amounts of which coated zinc plates inside the batteries, was or could be absorbed into the aquatic food chain. Mercury can enter the food chain when it is in a methylated (methyl mercury) or oxidized (ionic mercury) form. Mercury in its elemental form dissolves very slowly in water (30 to 100 years) and is not absorbed by aquatic organisms. Once dissolved, elemental mercury enters a natural cycle where it is volatilized into the atmosphere.

Professor Morel and Dr. Mason concluded that "it is expected that none of (the mercury) should be oxidized or methylated or become accumulated by the planktonic biota" and that they "expect to see no measurable biological effects due to the AToNs [batteries], either in the local sediments or in the water column." The alkaline (electrolyte) solution in the batteries is immediately neutralized in water and causes no harm.

The MIT findings were based on laboratory analyses and field studies conducted in the Chesapeake Bay. Significant findings:

> On a regional and global scale, the amount of mercury in AToN batteries is insignificant. Mercury is found in all waters and its concentration fluctuates over time.

2

Typical used AToN batteries were found, after their normal service life, to only contain a fraction of their original mercury content. The mercury remaining in the batteries is in an elemental form that is not absorbed by biological organisms, even if the batteries are not completely intact.

Well over half (60%) of the discarded batteries recovered to date were fully intact. Intact batteries were found not to leak measurable amounts of mercury.

COAST GUARD REACTION

Rear Admiral Peter A. Bunch, USCG, Chief of the Office of Engineering, Logistics and Development at Coast Guard Headquarters in Washington, DC characterized the research findings as positive:

> "The Coast Guard has been working closely with the Volpe National Transportation Systems Center to determine the environmental effects of discarded AToN batteries. These findings do nothing to relieve us of our responsibility to remedy the problem in accordance with federal and state requirements, but it is good to have solid scientific evidence that discarded AToN batteries are limited to a waste problem, and not a health or environmental hazard."

ADDITIONAL BACKGROUND

The U.S. Coast Guard operates approximately 16,500 lighted aids to navigation (AToN) consisting primarily of fixed navigational lights and buoys. AToN are located throughout the country on navigable waterways and in U.S. territorial waters in other parts of the world. Before the 1980's, lighted AToN were powered by various types and sizes of "one time use" wet cell/gel cell batteries. In the mid-1980's, the Coast Guard began converting most of its lighted AToN to solar power, substantially reducing its reliance on expendable batteries.

Prior to the 1970's, the Coast Guard, like the rest of the nation, did not have the environmental awareness that exists today. Although before 1973 there were no directives that said what to do with used batteries, it was never Coast Guard policy to dispose of them in the water. In 1973, the Coast Guard issued instructions that set procedures for battery recycling and proper disposal.

A small number of AToN batteries continue to get into the water when lighted AToN are hit by vessels, destroyed by bad weather or vandalized. It is Coast Guard policy to immediately report accidental battery losses to federal, state and local environmental authorities and to recover the batteries whenever safely possible. The Coast Guard is developing methods for

better attachment of batteries to lighted aids to prevent future losses and facilitate retrieval.
Since 1984, the Coast Guard has been picking up AToN batteries from various sites. Site surveys are being conducted in locations across the country. The Coast Guard, through the John A. Volpe National Transportation Systems Center, is conducting an analysis of known sites and is investigating the most effective site assessment, removal and remediation techniques.

An issue of concern is that greater damage not be done to the marine environment by removing batteries that may be covered over with natural growth (i.e. corals, algae, sponges) and used as "homes" by aquatic creatures. Additional study and consultation with regulatory and environmental agencies may be necessary to determine if removing the batteries is the best course of action.

The Coast Guard is working cooperatively with the U.S. Environmental Protection Agency Office of Federal Facilities Enforcement (OFFE) and affected state environmental agencies to develop a national remediation plan. Technical assistance is being provided by the U.S. Navy Supervisor of Salvage (SUPSALV), the National Oceanographic and Atmospheric Administration (NOAA) and the U.S. Environmental Protection Agency's National Estuarine Program. Recovery operations currently underway in Florida will provide information necessary to develop the national plan. The Coast Guard anticipates completion of an initial draft of the plan in the summer of 1994.